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INDIVIDUAL DIFFERENCES IN TEMPERATURE CHANGES OF WOMEN DURING THE COURSE OF THE MENSTRUAL CYCLE

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In a monograph published in 1904,[1] van de Velde, a Dutch gynecologist, pointed out that the temperature curve of adult women of normal health and child-bearing age rises and falls in a regular cycle corresponding to ovulation. In general, he indicated, the course of the ideal temperature curve is as follows: Ovulation occurs when the curve is at its lowest point. With ovulation the curve rises fairly regularly to a more or less accentuated peak. At this point the ovum may be considered to be entirely disintegrated, and a new one about to burst forth from the Graafian follicle. The temperature now rapidly drops to the next low, when once more ovulation occurs. It is during this last phase of lowering temperature, just prior to ovulation, that the menstrual flow begins. In the monograph referred to, van de Velde published the temperature curves of about a dozen women, ranging in age from about 25 to about 50. An examination of these curves strongly suggests the following conclusions: (1) that under normal circumstances the cycle is regular in its wave-like fluctuations; (2) that with the menopause it ceases to appear, the curve becomes irregular and lacks its former marked excursion; (3) that under certain abnormal physiological conditions the cyclical fluctuations fail to appear; but (4) that their reappearance can be artificially induced by "ovarian tablet" therapy; (5) that the ovarian cycle is presumably related to the menstrual cycle, but (6) that menstruation is not a necessary concomitant of ovulation (or rather, more precisely, of the temperature cycle).

[1] van de Velde, T. H. Ueber den Zusammenhang zwischen Ovarialfunction, Wellenbewegung, und Menstrualblutung, und über die Entstehung des sogenannten Mittelschmerzes. *Haarlem*, 1904.

In a further publication in 1930,[2] van de Velde refers to the above monograph. On the basis of further research during the intervening twenty years he has found reason to alter somewhat his earlier conclusions, but feels now certain of the following theses: "that the sudden rise in bodily temperature does not only herald the functional activity of the corpus luteum (follicular rupture, ovulation) but is caused by this function. Summit or maximum temperature and decline are similarly dominated by the efflorescence and the dispersion of the corpus luteum" (page 97). He publishes two further illustrations, this time one, of the "ideal" temperature chart of one of his cases; and another, the temperature chart of a woman concerning whom he had conclusive (surgical) evidence of the hour of ovulation, and whose temperature changes he obtained during the entire duration of pregnancy. The regular cycle of this latter woman was 28 days. The occasion of conception was determinable from the fact that the date of the only coitus, subsequent to the commencement of the last menstrual flow, was definitely known. Immediately after this date (the fifteenth day after commencement of the menstrual flow) temperature rapidly rose to a new high, where it remained, fluctuating irregularly, with no further evidence of recurrent cyclical changes until the seventh menstrual "month." During the last 70 or so days before parturition the temperature curve gradually fell, assuming a form suggestive of the regular wave-like fluctuations of the pre-pregnancy period. Presumably—although van de Velde makes the observation neither in his graph nor in the body of his text—the curve immediately after parturition reverted to the "normal" wave-like fluctuations corresponding to the ovulation cycle. From all of this confirmatory data, van de Velde argues that the temperature curve is definitely related to ovulation, of the progress of which it is a most reliable index.

The manner in which van de Velde obtained his temperature readings is worthy of note. Experiment, reported in the earlier publication, had demonstrated to his satisfaction that the most satisfactory readings (the least subject to variable influences) were those obtained in the morning, shortly before rising. The best measure of temperature, furthermore,—although the evidence adduced to confirm this statement is less clear,—was obtained from the retention of a "maximal" (clinical) Celsius (centigrade) thermometer under the armpit (side not indi-

[2] van de Velde, T. H. Ideal Marriage, its Physiology and Technique. *New York. Covici Friede.* 1930.

cated) for a quarter of an hour.[3] The temperature curve itself was smoothed to some extent by the simple device of adding to the temperature for any given day that for the day preceding it and that for the day following it, and dividing the sum by three—a procedure referred to by van de Velde as Bloxam's method.

THE TEMPERATURE RECORD OF H

In the case reported below an attempt has been made to investigate in more detail some of van de Velde's findings, and to indicate further suggestive avenues of research.

H is a 26-year old woman, of apparently normal health and physical condition, married three years, but without children (because of the consistent use of an adequate contraceptive device). About four months before the record of temperatures here described was commenced, H underwent a myomectomy (fibromyoma in the uterine wall; removed without complete transection of the uterine wall; rapidly healed).

Table 1 constitutes the table of morning *oral* temperatures of H, taken by means of a Becton Dickinson (No. 44532) clinical thermometer at about 7 a. m. just before rising. Although every effort was made to adhere to a consistent hour of the morning at which to take the temperature reading, there were occasions when the reading was taken as much as an hour either before or after this established time. Especially was this true of vacation times, when late rising resulted in a series of days on which readings were taken at about eight o'clock. On only two occasions were readings taken at more than an hour earlier than 7 a. m. That the days on which perhaps significantly irregular hours of temperature reading prevailed may be identified, those mornings on which the reading was taken at any time an hour or more either way from 7 a. m. are indicated by means of the letter *"t."* Rarely did the deviation from 7 a. m. exceed 90 minutes. On three occasions the readings were not taken. The temperatures for those days were estimated as the average of the temperatures of the immediately adjoining two days. They are indicated by means of a question mark (?). The days on which H suffered from what appeared to be a common cold are indicated by means of the letter *"c"*; those during which she was subject to an attack of pyelitis, with the letter *"i."* During her residence in a southern state (commenced about five months before the commencement

[3] It is not stated whether any adequate attempt was made to experiment with rectal temperatures, which one would expect to yield the most reliable data.

TABLE 1

*Table of Oral Temperatures of H Taken at or About 7 a.m. Every Day During Thirteen Menstrual Cycles.**

DAY OF CYCLE	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
1	810	790	750	800c	790h	830	820	800t	800	820	800	800	800
2	750	800	760	800c	800h	820	840t	760t	800	820	830	770	800
3	820	780	790	760	810h	800	810	800t	790	780	800	800	800
4	800	800	780h	760?	790	780t	800	80	780h	840t	760	800	780
5	78	770	72t	77	78h	720	810t	76	770h	790t	780	80	760
6	78	78	80h	80t	80h	811	78	78	79h	800	800t	80	810t
7	78	78	80	78h	78h	84t	76t	77	82	80	810	77	77
8	78	78	72	81h	78h	82t	81t	78	78	80	79	80	80
9	81	76	79	80	82h	74t	76t	77	78	78	79	78	82
10	80	82	79	88h	81h	74t	80t	79	84t	76	73	80	79
11	81	79	80	86h	78h	80	79t	79	80t	77c	80	80	77
12	82	78	79h	79	83h	84t	79t	84	81h	80c	76	80	77?
13	85	80	81h	81	83h	80t	80t	80	80	80tc	83	81	76
14	88t	80	83	82h	86	80t	81t	82	86	81c	80	80	78
15	83	86	83	83	86	82t	83ti	83	83	80c	83	82	80
16	83	84	83	85	83t	80t	81ti	86	83	86	84	85	85
17	82	80h	84	82	87	84t	84ti	85	87t	81	82	84	82
18	84	83ht	73	86	86t	80t	81ti	83	86	82	85	86t	85
19	84	80h	85th	85	83	78t	81ti	82	82	83	85	84t	85
20	84	84	86	85	86	84t	86ti	84	86	80	83t	85	83c
21	84?	82	84h	86	82t	86t	86t	82	85	85	86	85	86tc
22	84	86	84	87	88	84	83ti	82	86t	87	84	83	87tc
23	86	82	82	86	82	84t	85ti	83	84	86	84	85	86c
24	80	82	84h	86	—	82t	86ti	83	84	84	85	86	85
25	—	83	86	86	—	86t	85ti	80i	81	84	81	84	84
26	—	81	82t	78th	—	85	79t	—	80	81	84	85t	83
27	—	76	80	80h	—	85	80	—	—	83	83	80	70t
28	—	—	—	—	—	—	—	—	—	—	83	—	—
29	—	—	—	—	—	—	—	—	—	—	79	—	—

* For explanation of this table, see text.

of this record) H developed for the first time full symptoms of "hay-fever," an ailment which lasted intermittently until her departure for a northern state, some time during the fifth menstrual cycle of this record. Thereafter the symptoms appeared only once, for a few days after the arrival of some boxes of clothing and household goods from the former home in the south. Days on which clear signs of "hay-fever" were manifest are indicated by means of the letter *"h."* Days during which any amount of menstrual flow was observed are indicated by means of the letter *"O."* In interpreting Table 1, as well as every other table in this article, it is to be noted (a) that *all temperatures here recorded are written without the initial figure 9, and without the insertion of the decimal point.* (Thus a temperature of 98.1 would be written as 81); (b) that *every temperature recorded is assumed to be the temperature at 7 a. m.*; and (c) that *any remark recorded next to a temperature reading has reference to events which occurred during the preceding 24 hours.* (This accounts for the fact that on Figure A some of the "first-day" temperatures are recorded after the actual onset of the menstrual flow.)

Figure A represents the serial distribution of temperatures recorded in Table 1. The commencement of the menstrual flow (occurring during the 24-hour period preceding the first temperature reading of the cycle) is indicated by a vertical line. The smoothed curve is made up by averaging the temperature of every day with those of the day before and the day following. This procedure is the same referred to (and used) by van de Velde as Bloxam's method. The consistent regularity of the temperature fluctuations in this illustration is evident. As with the curves of van de Velde's cases, the menstrual flow commences while the temperature is dropping. After reaching its nadir, at some stage usually a few days after the cessation of the menstrual flow, the curve rises to a peak (not always very clear, unless smoothed still further, because of the fact that often a minor peak adjoins it), and once more drops to low through the menstrual flow stage.

As a partial control on the temperature variations of H, a record was kept of the daily oral temperatures of her husband, H', readings being taken (by means of a different clinical thermometer), at the same time as H's readings, every day for 106 consecutive days. (A few gaps in the record had to be estimated in the way described above.) The smoothed curve of 3-day averages of these temperatures is illustrated in Figure B, where it is plotted on the same scale as the corresponding

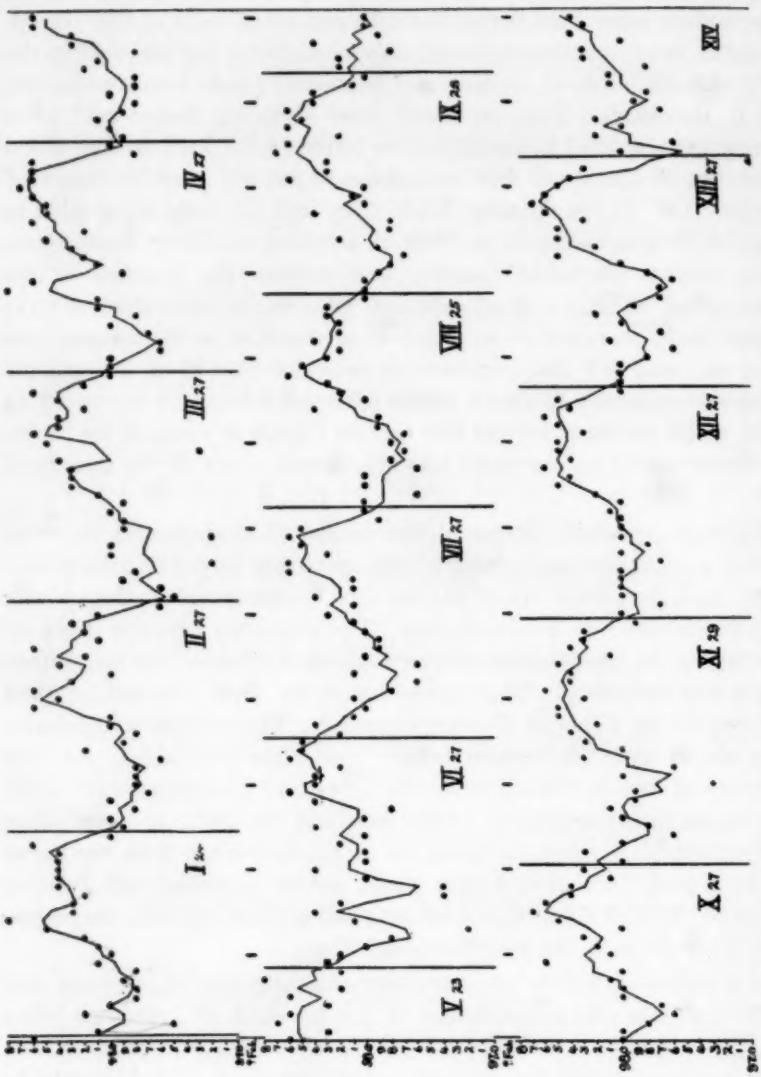

FIG. A. SERIAL DISTRIBUTION OF MORNING ORAL TEMPERATURES OF H DURING ONE YEAR (THIRTEEN CONSECUTIVE MENSTRUAL CYCLES), WITH CURVE OF 3-DAY MOVING AVERAGES FITTED TO COÖRDINATES

smoothed-averages curve for H. It will immediately be noted, first, that the husband's average temperature is significantly lower than that of H; and, second, that, despite the fact that in general both persons are subject to roughly the same weather conditions, consume the same kind of foods, usually have colds together, and sleep in the same bed, the husband's temperature does not exhibit the significantly consistent wave-like fluctuations so characteristic of H's temperature. When the actual daily temperatures of H's husband during these 106 days were correlated with those of H, the product-moment correlation, r, was found to be 0.17. No adequate explanation of this agreement can be offered here other than the environmental similarities referred to above. At least one apparently common fluctuation, marked *"a"* on the graph, was attributable to a severe cold which both experienced at the same time.

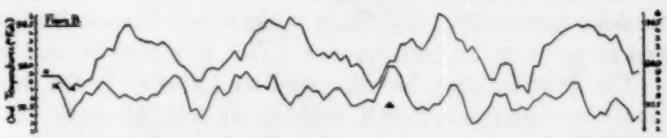

FIG. B. SERIAL CURVES OF MORNING ORAL TEMPERATURES OF H AND H' (3-DAY MOVING AVERAGES) COMPARED DURING 106 CONSECUTIVE DAYS —At point marked "a," both together experienced a severe cold.

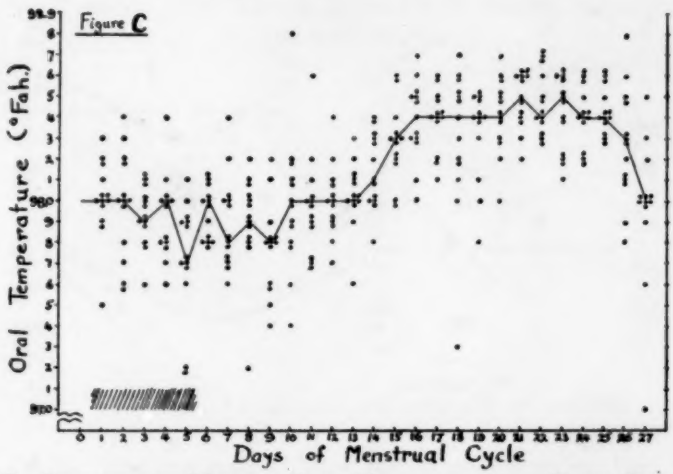

FIG. C. COMPOSITE OF MORNING ORAL TEMPERATURES OF H FOR THIRTEEN CONSECUTIVE MENSTRUAL CYCLES (STANDARDIZED FOR LENGTH OF 27 DAYS), WITH CURVE OF MEANS OF COLUMNS INSERTED—Cross-hatching represents median duration of menstrual flow.

FIG. A. SERIAL DISTRIBUTION OF MORNING ORAL TEMPERATURES OF H DURING ONE YEAR (THIRTEEN CONSECUTIVE MENSTRUAL CYCLES), WITH CURVE OF 3-DAY MOVING AVERAGES FITTED TO COÖRDINATES

The other coincident fluctuations the writers are not able to explain. It is doubtful that they can be discarded without more careful consideration; but at present their presence suggests nothing to the writers which may be determined without reference to further research.

THE TYPE-CURVE OF THE TEMPERATURE CYCLE

In itself the curve traced in Figure A is not especially novel. It is perhaps somewhat uncommon in that it represents the temperature changes of a presumably healthy woman of child-bearing age, recorded over an unusually long period of time. But, at the suggestion of Dr. E. B. Wilson of the Harvard School of Public Health, the data of the various cycles reported in Table 1 were plotted as a composite, with a view to discovering whether some fundamental cyclic fluctuation common to all actually exists, or whether, by so fusing the different cycles, the fluctuations apparent in any single cycle would become blurred and so reduced as to be of no consequence. This is a step beyond van de Velde's. The problem may be expressed as follows: Is the variation strictly speaking cyclic, or merely accidental? and, if cyclic, of what nature is the characteristic or type-curve of the cycle?

To make possible the construction of this composite curve, it became necessary to standardize all of the actual cycles for length. Twenty-

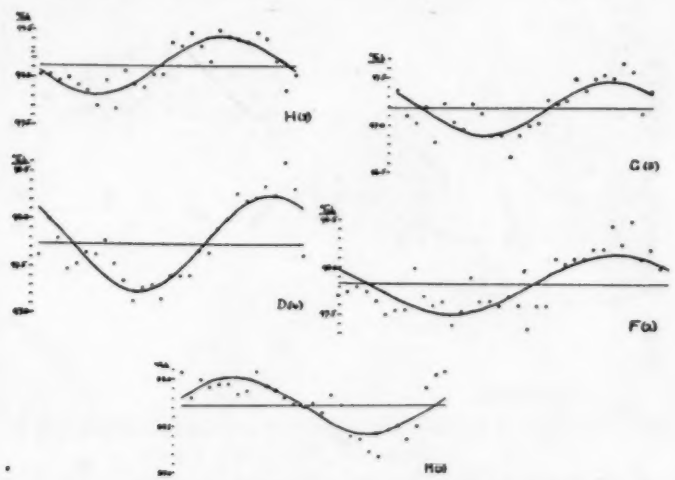

FIG. D. TYPE-CURVES, DETERMINED BY HARMONIC ANALYSIS, OF FIVE DIFFERENT WOMEN, INCLUDING H—Plotted coördinates represent means of original observations.

seven days was selected as the standard, all other-length cycles being corrected accordingly. The process of correction involved simple interpolation from the actual records.[4] No similar correction was made for the differences in time of reading introduced by thus contracting or expanding the length of the actual cycle. Apart from the fact that a standard measure of temperature variations during the day for H has not been determined, it is doubtful that corrections so made would affect the final type-curve significantly. Table 2 constitutes the table of data in Table 1, but standardized for length. The cycles which have been corrected are indicated by asterisks (*).

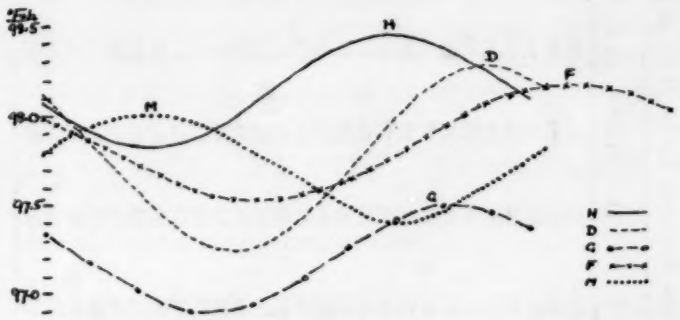

FIG. E. TYPE-CURVES AS ILLUSTRATED IN FIG. D., PLOTTED COLLECTIVELY ON THE SAME GRAPH

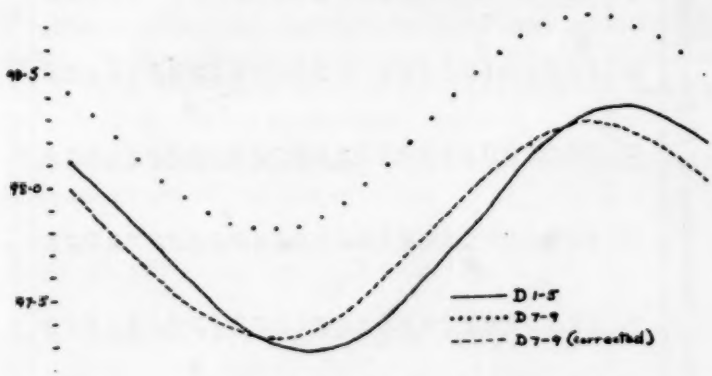

FIG. F. TYPE-CURVES OF D. For further explanation see text.

[4] Facilitated by interpolating directly from the actual curve itself. It was not likely that interpolating from a smoothed curve of the cycle would give rise to any significant different change in the end-product, namely, the determination of the average temperature for each separate day of the standard cycle.

TABLE 2

Table of Oral Temperatures of H Taken During Thirteen Menstrual Cycles Daily on Rising. Cycles Standardized

DAY OF CYCLE	I*	II	III	IV	V*	VI	VII	VIII*	IX*	X	XI*	XII	XIII
1	81	79	75	80	79	83	82	80	80	82	80	80	80
2	78	80	76	80	80	82	84	76	80	82	83	77	80
3	81	78	79	76	81	80	81	79	79	78	79	80	80
4	81	80	78	76	80	78	80	80	78	84	77	80	78
5	79	77	72	77	79	72	81	77	77	79	79	80	76
6	78	78	80	80	78	81	78	78	79	80	81	80	81
7	78	78	80	78	80	84	78	78	82	80	80	77	77
8	79	78	72	81	78	82	81	78	77	80	80	80	80
9	78	76	79	80	78	74	76	78	79	78	79	78	82
10	81	82	79	88	81	74	80	78	78	76	75	78	79
11	80	79	80	86	82	80	79	79	82	77	78	80	77
12	81	78	79	79	80	84	79	80	81	80	77	80	77
13	82	80	81	81	79	80	80	83	80	80	80	81	76
14	84	80	83	82	83	80	81	80	84	81	83	80	78
15	86	86	83	83	83	82	83	82	84	80	83	82	80
16	87	84	83	85	85	80	81	83	83	86	83	85	85
17	84	86	84	82	86	84	84	85	84	81	85	84	82
18	82	83	73	86	85	80	81	85	87	82	84	86	85
19	84	80	85	85	84	78	81	84	85	83	84	84	85
20	84	84	86	85	87	84	86	82	83	80	85	85	83
21	84	82	84	86	86	86	86	83	86	85	84	85	86
22	84	86	84	87	84	84	83	83	85	86	85	83	87
23	84	81	82	86	85	84	85	82	86	86	82	85	86
24	84	82	84	86	84	82	86	82	84	84	84	86	85
25	84	83	86	86	84	86	85	83	84	84	83	84	84
26	86	81	82	78	88	85	79	83	81	81	83	85	83
27	80	76	80	80	82	85	80	80	80	83	79	80	70

* Cycles which have been standardized for length.

Figure C represents the composite cycle of daily temperatures of the thirteen cycles standardized for length. The curve of means of the columns is imposed upon the distribution of the temperature points. When smoothed by means of mathematical analysis, it presents a curve in every essential similar to the first outline in Figure D—an outline referred to hereafter as the type-curve for H. Characteristics of this curve are discussed later.

CONSTRUCTION FORMULAE

A mathematical analysis, by means of which to determine the equation for the curve of best fit to the coördinates of the mean temperatures in the composite cycle reported above, was supplied the writer by Dr. P. J. Rulon of Harvard University.[5] This procedure, involving Fourier analysis, yields a generalized equation for all curves of the nature:

$$y = a_0 + a_1 \operatorname{Cos} \frac{2\pi k}{n} + b_1 \operatorname{Sin} \frac{2\pi k}{n}$$; in which a_0 is the mean of the coördinates of the composite curve;

and $a_1 = \dfrac{2\Sigma\left(\dfrac{\Sigma fd}{N} \cdot \operatorname{Cos}\dfrac{2\pi k}{n}\right)}{n}$; and $b_1 = \dfrac{2\Sigma\left(\dfrac{\Sigma fd}{N} \cdot \operatorname{Sin}\dfrac{2\pi k}{n}\right)}{n}$.

In each of the last two equations Σfd equals the sum of the reported (or estimated) temperatures for a given day, k, in a series of standardized cycles; N equals the number of complete cycles observed; and n equals the number of days in the standardized cycle.

The method yields the following formula for the type-curve for H, as determined from 16 consecutive cycles:

$$y = 98.148 - .057 \operatorname{Cos} \frac{360}{28}k - .291 \operatorname{Sin} \frac{360}{28}k.$$

On three cycles (II, VII, XII) taken at random it yields:

$$y = 98.126 - .055 \operatorname{Cos} \frac{360}{28}k - .295 \operatorname{Sin} \frac{360}{28}k.$$

[5] Dr. Rulon hopes to publish the method in the near future.

With indices of reliability appended, the constants included in these equations are as follows:[6]

	H (16)	H (3)
a_0	98.148 ± .008	98.126 ± .011
a_1	−.057 ± .010	−.055 ± .016
b_1	−.291 ± .030	−.295 ± .038

It may be seen that, at least in the case of H, the equation for three cycles is not greatly different from that for 16 cycles.

INDIVIDUAL DIFFERENCES IN TYPE-CURVE

To what extent, however, does the type-curve for H differ from those of other women? This involves the question of individual differences, a phenomenon possibly of diagnostic value, although, in view of the present lack of data, not proven. In Figure D are reproduced the type-curves of five different women. The first is that of H (3 cycles at random); the second, that of D (4 consecutive cycles); the third, that of G (3 consecutive cycles); the fourth, that of F (2 consecutive cycles); and the fifth, that of M (3 consecutive cycles). Assuming that the similarity between the 16-cycle and 3-cycle curves in the case of H may perhaps warrantably be generalized to apply to the curves of other women as well, it is not improbable that each other curve here reproduced may be looked upon as at least a fairly close approximation to the type-curve of the woman concerned. If this argument be valid, we have an interesting series of individual differences. The constants for the type-curves are reproduced below:

	a_0	a_1	b_1
H	98.126 ± .011	−.055 ± .016	−.295 ± .038
D	97.743 ± .017	+.365 ± .068	−.352 ± .021
G	97.188 ± .144	−.157 ± .020	−.235 ± .120
F	97.830 ± .086	+.163 ± .114	−.268 ± .130
M	97.723 ± .022	+.077 ± .059	+.277 ± .029

The curves themselves are illustrated below, separately in Figure D, and collectively in Figure E. It is to be noted that curve M is the antithesis of the others.

[6] The reliability formulae also were supplied by Dr. Rulon.

The following individual differences, possibly of diagnostic value, are to be noted:

1. *Length:*
   Differences in length of standard cycles;
2. *Average temperature:*
   Differences in average temperature;
3. *Amplitude:*
   Differences in amplitude of the curve (temperature at zenith minus temperature at nadir)[7];
4. *Nadir ratio (or zenith ratio):*
   Differences in the day, considered as a proportion of the entire cycle-length, upon which the curve reaches its nadir (or zenith) after day $k = 0$;[7]
5. *Transit ratio:*
   Differences relating to the day, considered as a proportion of the entire cycle-length, upon which the curve in its *downward* course crosses the line representing the average of the coördinates, after day $k = 0$.[7]

Of these differences, numbers 3, 4 and 5 are determined by the constants a_1 and b_1, and are probably of most value as diagnostic characteristics. Rulon has derived equations by means of which to identify and determine characteristics 3, 4, and 5, as follows:

(3) Amplitude: $2\sqrt{a_1^2 + b_1^2}$

(4) *a.* Nadir temperature: $a_0 - \sqrt{a_1^2 + b_1^2}$

b. Zenith temperature: $a_0 + \sqrt{a_1^2 + b_1^2}$

c. Time of nadir or of zenith:

$$k = \frac{n}{2\pi} \cdot \mathrm{Sin}^{-1} \pm \sqrt{\frac{b_1^2}{a_1^2 + b_1^2}}$$

(5) Time of Transit:

$$k = \frac{n}{2\pi} \cdot \mathrm{Sin}^{-1} \pm \sqrt{\frac{a_1^2}{a_1^2 + b_1^2}}$$

[7] Because of the nature of the harmonic analysis technique here employed, each distance (a) between time of zenith and time of nadir, and (b) between time of upward transit and time of downward transit, equals exactly one-half of the total cycle; and the amplitude is evenly divided above and below the average line, a_0.

For the type-curve equations here reported, these may be tabulated as follows:

	LENGTH OF CYCLE *Days*	AVERAGE TEMPERATURE ° *Fah.*	AMPLITUDE ° *Fah.*	NADIR RATIO	ZENITH RATIO	DOWNWARD TRANSIT RATIO
H(3)	27	98.126	.60	.22	.72	.97
D(4)	28	97.743	1.01	.38	.88	.13
G(3)	27	97.188	.56	.34	.84	.09
F(2)	35	97.830	.62	.34	.84	.09
M(3)	28	97.723	.58	.71	.21	.44

Just what these differences mean the writers are not prepared to hazard a guess. They are proffered for what they are worth, as suggestions. More cases are needed; and it is without question that, to determine whether curves of this nature actually have diagnostic significance of therapeutic value, full medical, especially endocrine, histories of subjects should first be obtained. It is hoped later to be able to present such material.

Assuming that van de Velde's statements are correct, in that (1) the nadir of the curve represents the date of ovulation, and (2) the zenith represents the date at which the final disintegration of the ovum takes place; and assuming again (3) that the period of ovulation (as determined by harmonic analysis) actually does constitute one-half of the period of the menstrual cycle, and (4) that the proportional position of the zenith in the complete cycle varies from one woman to another; might it not be possible that crude statistical grouping of conception data, without due regard to type-curves of temperature, such as that recently attempted in an interesting article by R. L. Dickinson,[8]

[8] The "safe period" as a birth control measure, *Amer. J. Obstet. & Gynec.*, 1927, 14, 718-730.

actually would tend to confuse the issue, yielding a false impression concerning the lack of safety of the so-called "safe-period"? It might be interesting, knowing the temperature type-curves of women known to have and to make use of a "safe" period, to discover whether or not the period between the temperature zenith and the commencement of the menstruum really is a "safe" period.

An attempt was made by the writers to observe changes in mood, etc., during the menstrual cycle. Records here, unfortunately, are especially difficult to maintain, both because of the fleeting nature of the phenomena, and because of the difficulty of establishing objective criteria of measurement. Consequently, although the writers suspect the incidence of a brief period of emotional depression shortly after the beginning of the rise in temperature, there is insufficient evidence as yet to warrant a definite statement to that effect. It is hoped later to be able to present some suggestive evidence on that point.

NOTE

Subsequent to the development of the above material, there have come to hand further temperature data on cases D and M. D has submitted five more cycles (5-9), and M three (4-6).

During the sixth cycle D broke her thermometer and obtained another. Thus we have for her cycles 1 to 5 on one thermometer, and cycles 7 to 9 on another. The table published below demonstrates a pronounced difference in average temperature for D(1-5) compared with D(7-9)—a difference attributable in all probability to the difference in thermometers. This observation probably applies also to some extent to the differences in average temperature already reported between individual cases. Comparison of the formulae for D(1-5) and D(7-9) reveals quite pronounced differences in a_1 and b_1. The curves plotted one upon the other are illustrated below. The plain line represents the curve D(1-5)—substantially the same as that for D(1-4) reported above; the dots represent the actual curve D(7-9); while the broken line represents the same curve D(7-9) corrected by an amount equal to —.474 degrees at each coördinate to allow for the difference in average temperature for the two curves. The phase of the curve has shifted noticeably; and the amplitude is slightly affected. Whether the changes are due to the use of a different thermometer, or to changes in the condition of the subject it is not possible to say. Nevertheless the general type of the curve remains substantially unaltered, and is characteristically different from the four other type-curves already reported.

In the case of M, although the mode of life during the latter three cycles was considerably different from that during the former three, the most noticeable change in formula is the increase in average temperature. The formula for M(1-3), M(4-6), and M(1-6) are however all essentially similar, with only small differences between them. The general shape of the curves, when plotted, remains in almost every respect unchanged.

	FORMULAE			AMPLI-	NADIR	ZENITH	DOWN-WARD
	a_0	a_1	b_1	TUDE	RATIO	RATIO	TRANSIT RATIO
D(1-4)	97.743	+ .365	— .352	1.01	.38	.88	.13
D(1-5)	97.768	+ .350	— .373	1.02	.37	.87	.12
D(7-9)	98.242	+ .180	— .415	.90	.33	.83	.07
M(1-3)	97.723	+ .077	+ .271	.58	.71	.21	.44
M(4-6)	97.882	+ .134	+ .246	.56	.67	.17	.42
M(1-6)	97.792	+ .106	+ .264	.57	.67	.17	.44

A STUDY OF FACTORS ASSOCIATED WITH THE GROWTH AND NUTRITION OF PORTO RICAN CHILDREN*

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PLAN OF THE STUDY

Diet and disease are believed to be likely to affect the growth and development of children. We sought evidence of this effect by studying the physical measurements of Porto Rican children. We proceeded on the hypothesis that the diet of a large proportion of Porto Rican children is probably deficient and that disease in the form of intestinal parasitic infestation, as well as possibly other forms of tropical disease, is sufficiently prevalent to cause definite manifestations of deficiency in growth and development of Porto Rican children. Evidence of deficiencies presupposes comparisons with standards or judgments as to presumable expectation.

As no standards are available as to what measure of growth attainment should be expected for a Porto Rican child of a given age and sex, we selected several measurable factors which are likely to be associated with marked differences in dietary and disease conditions and then studied the relationship of these measurable factors to manifestations of growth and development. The possible effect of such other factors as climate, race, and nativity stock are no doubt important considerations which might vitiate our conclusions, but in the absence of definite knowledge of the influence of these factors, we can only take such precautions as are practical for the control of these factors, and qualify our conclusions subject to more adequate knowledge of the effect of climatic and genetic influences.

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* An inquiry into the health, nutritional, and social conditions in Porto Rico as they may affect children was made at the request of President Hoover. The study here presented is part of this inquiry which was made by the American Child Health Association under the direction of Samuel J. Crumbine, M. D., the General Executive of the Association.

The following brief statement of the findings indicates the approach made to the problem. We found the physical measurements of Porto Rican children to be generally consistent with the hypothesis that some factor associated with socio-economic status influences the growth and development of the children. The differences found between Porto Rican children and continental United States children are in accord with this hypothesis, although we recognize that this difference may be due wholly or in part to other factors such as climate, race and nativity stock. We found a definite difference between urban and rural Porto Rican children that is in harmony with the view that hookworm may affect the growth and development of children and the well-known fact that hookworm is more prevalent among rural children. As intestinal parasitic infestation and deficient diet are probably associated with the poorest socio-economic groups, and less intestinal infestation and more liberal diet with the better economic groups, the findings are considered consistent with the hypothesis that diet and disease may cause a deficiency in the growth and development of Porto Rican children.

The growth and development measurements used in this Report are based upon the research (published and unpublished) by the American Child Health Association.* All our comparisons with children in continental United States are made with reference to the American Child Health Association data. Material for this comparison was developed from a representative sampling of white American-born public school children.

RACIAL INFLUENCE

As it is recognized that Negro hybridization may have a marked effect upon anthropometric traits as compared with members of the white race, we attempted to eliminate this complicating factor, so far as possible, by excluding all recognizable Negro children from the data.

Although the problems we are concerned with probably apply as much to Negro and mulatto children as to those of Spanish origin, the simplest approach to our problem seemed to be to study a group of white children. Our study of native-born white children of the United States has provided a basis for interpretation of physical measurements and for comparison.

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* Raymond Franzen. Physical Measures of Growth and Nutrition. School Health Research Monograph Number II. American Child Health Association, *New York City*. 1929. 138 pages.

In so far as our findings point to disease and poverty conditions, it appears likely that similar conclusions could be expected from a study of Negro children. It appears safe to assume that no better conditions with respect to disease and poverty prevail among Negro families.

As racial barriers may not be as rigid as in the United States, and as no ready scientific criterion is available for distinguishing Negro hybridization, we would not claim that our data are entirely free from all Negro influence. However, we took the precaution to measure children only in those regions of the island that are generally conceded to be largely free from Negro mixtures. We had the assistance of experienced directors of the Insular Department of Education and district educational supervisors in making such a selection of schools. In the schools selected, the teachers were asked to send for measurement all white children of an age group so that Negro and mulatto children were eliminated by the teachers, who knew the children and their families. Finally, each child was classified by both the anthropometrist and the examining dentist.

This classification was a rating scale judgment estimated on the basis of skin color and other apparent negroid characteristics:

Race 0 represented the group judged to be entirely free from Negro characteristics. Race 1 represented the group judged with almost no doubt to be free from Negro influence on the basis of the way the features impressed the observer. With the slightest suspicion as to skin color, even though dark complexion might be explained as sun effect, the case was classified as Race 1. The slightest doubt as to features was distinguished as not white and scored with Race 1 or 2, according to the degree of suspicion. Race 2 included the cases with definite suspicion. Race 3 included the cases with at least one definitely negroid feature. Race 4 included cases definitely Negro, but suspected as not being full-blooded Negro. Race 5 was reserved for the cases that were judged to be full-blooded Negro.

With these precautions and the limitation of our analysis to children classified as Race 0 and Race 1, the data are considered reasonably free from the complication of Negro influence.

Although the early history of the island is not entirely clear as to how general has been the admixture of Indian blood with the Spanish, we have regarded the influence of Indian hybridization as probably not of great significance to our conclusions.

All our observers were dentists trained in the United States and white native university graduates employed for making the anthropometric measurements. The objectivity of these ratings on a three point scale (Race 0, 1, and 2) was computed by comparing the ratings of the anthropometrists with those of the dentists who examined the same children. These objectivity coefficients varied from .52 to .67. When a wider range of race variation was considered with children classified as Race 0, 1, 2, 3 and 4, we found objectivity coefficients from .91 to .96. This sampling did not happen to include any Race 5 children.

A COMPARISON OF ANTHROPOMETRIC TRAITS OF PORTO RICAN CHILDREN WITH THOSE OF CHILDREN OF CONTINENTAL UNITED STATES

We find that Porto Rican children are smaller in all anthropometric traits than children of the same age and sex in the continental United States. This comparison is presented in Table 1. That the difference is a significant one is shown by the Standard Difference * (or Critical Ratio) computed for each comparison and included in the table. When this ratio is greater than 3, we may assume that for samples of children taken in the same manner as these, the probability that the differences might have occurred by chance are negligible.

It may also be noted that 10-year-old Porto Rican boys and girls are generally smaller than 8-year-old children in continental United States.

SAMPLING

The adequacy of the sampling of continental children is presented in the Research Monograph of the American Child Health Association already mentioned.

The similarity of the socio-economic groupings of the two samples of rural children (presented in the Appendix of this Report, Fig. 2) indicates the basis for our judgment that the sampling is fairly representative of white rural Porto Rican children exclusive of those on the coastal plains. The urban children were taken at random from 19 cities

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* Standard Difference is here used to mean $\frac{M_x - M_y}{\sqrt{\frac{\sigma_x^2}{n_x} + \frac{\sigma_y^2}{n_y}}}$ where x refers to measurements of United States children and y refers to measurements of Porto Rican children.

TABLE 1

Comparison of Nine Anthropometric Traits in Children of Continental United States and Porto Rico

TRAIT	AVERAGE MEASUREMENTS								STANDARD DIFFERENCES			
	10-year-olds				8-year-olds				10-year-olds		8-year-olds	
	Boys		Girls		Boys		Girls					
	U. S.	P. R.	U. S.	P. R.	U. S.	P. R.	U. S.	P. R.	Boys	Girls	Boys	Girls
Height	54.5	50.3	54.4	50.7	49.9	47.0	49.6	47.2	34.1	29.5	9.7	7.8
Bisacromial	29.7	26.7	29.4	26.8	27.3	24.8	27.1	24.9	39.1	34.4	13.7	13.5
Chest Breadth	42.3	39.9	41.4	39.7	40.4	38.1	39.6	37.4	20.6	13.9	10.3	9.0
Chest Depth	31.2	30.1	30.6	29.5	30.3	28.9	29.6	27.5	10.9	9.9	6.9	9.5
Hip Width	24.5	21.9	24.7	22.5	22.7	20.2	22.8	20.7	36.4	28.7	16.9	13.5
Arm Girth	38.8	34.3	38.9	35.2	35.9	32.4	35.8	33.1	27.3	20.8	10.1	8.5
Calf Girth	27.4	24.9	27.8	25.3	25.3	23.3	25.5	23.4	26.2	24.9	9.7	10.5
Subcutaneous Tissue												
over Biceps	25.8	22.8	29.7	25.8	...	...	...	...	16.2	19.6	...	...
over Triceps	74.2	61.5	85.8	71.0	...	...	...	...	23.0	27.1	...	...
Number	788	879	909	902	500	112	500	114	...	...	...	...

with a similar distribution over the Island plus 482 cases from San Juan selected by schools to provide a representative socio-economic distribution of the city. For the smaller cities the sample included all the 10-year-old children in school for each city. As the anthropometric traits of the 10-year-old children show a marked similarity of the means in the two race groups (see Table 2), we feel it is likely that the sampling is adequate for our conclusions. The consistency of the various findings throughout this study contributes to our judgment that the children measured were a sufficiently representative sample to justify the conclusions as qualified.

Although it may be noticed in Table 2 that in every comparison Race 1 is slightly smaller than Race 0, we cannot be certain that this finding is significant. The attempt to make a racial distinction might have resulted in a socio-economic distinction which could be reflected in consistently smaller dimensions for Race 1. The means, sigmas, and intercorrelations were computed for a few cases in each of the other race groups, i. e., Races 2, 3, 4 and 5, but the data were inadequate for deciding whether Negro hybridization had any important effect on growth.

TABLE 2

Anthropometric Traits in Children of Porto Rico by Race Groups
10-year-olds

	AVERAGE MEASUREMENTS OF BOYS		AVERAGE MEASUREMENTS OF GIRLS	
	Race 0	Race 1	Race 0	Race 1
Height—inches	50.4	49.9	50.8	50.5
Bisacromial	26.7	26.6	26.8	26.7
Chest Breadth	40.1	39.6	39.7	39.4
Chest Depth	30.1	29.9	29.6	29.2
Hip Width	21.9	21.7	22.6	22.4
Arm Girth	34.5	34.0	35.4	34.8
Calf Girth	24.9	24.7	25.3	25.0
Subcutaneous Tissue over Biceps	23.0	22.5	26.1	25.2
Subcutaneous Tissue over Triceps	62.1	60.4	71.6	69.9
Number	548	331	555	347

WEIGHT AND HEIGHT

A study completed shortly before our inquiry has shown that Porto Rican children have no marked tendency to weigh less than continental children of the same age, sex, and height. Payne, Berrios and Martinez

Rivera * showed little difference between a curve of weight : height ratios $\left[1000 \frac{\text{(weight in pounds)}}{\text{(height in inches)}^3}\right]$ for different age groups of Porto Rican children and the curve of continental children by Bardeen. As Bardeen's data are from measurements of children by many observers, they probably represent a widespread sampling of United States children. Furthermore the ratios by Bary plotted in the Payne study from Porto Rican children appear somewhat higher than the Bardeen curve, and his figures from Yabucoa and Rio Piedras indicate that slightly fewer Porto Rican children are 10 per cent or more underweight for height than were found by Clark and Sydenstricker in their large sampling of continental children.

The significance of these findings is interpreted by us as indicative of a similarity of body build between Porto Rican children and continental children. At least we should judge that they indicate no tendency for Porto Rican children to be more slender in build than continental children of the same height, age, and sex. Our position is based upon the analysis of weight in relation to various physical measurements as presented in Research Monograph Number II of the School Health Study of the American Child Health Association. This research has shown that the differences in weight within an age group of school age children in United States are so closely associated with differences in bony dimensions other than height, that weight for a given height is regarded as more representative of body build than of nutritional status. Weight is clearly a measurement of over-all size and its relation to nutrition must be the result of those nutritional factors that are associated with bony growth differences rather than with differences in musculature or adipose tissue.

As skeletal size is probably affected by genetic influences, the use of an over-all measure, such as weight, must manifest genetic differences in children to a considerable degree and any effect upon weight that may be associated with nutritional influences apart from genetic effects must be the result of those influences that are exerted over such a period of time as would affect the bony dimensions. Our study of the possible

* George C. Payne, Manuel B. Berrios, and Ezequiel Martinez Rivera. Heights and weights of children in three communities of Porto Rico. *The Porto Rico Journal of Public Health and Tropical Medicine (San Juan)*, 5: 344-356. March, 1930.

manifestations of nutrition and disease upon Porto Rican children, therefore, considered separately the bony dimensions and also indices of musculature and adipose tissue rather than an over-all index of size or body build, such as weight.

Although we did not measure the weight of Porto Rican children, our analysis of the interrelationships of all the traits measured in the Porto Rican children compared with our findings on the continent indicate the probability that the weight of Porto Rican school age children is largely determined by the skeletal build. These interrelationships are on file in the offices of the American Child Health Association, and available there for those desiring further study. The high relationships of bony dimensions with weight in continental children prevailed consistently in many groups. As the data included many American children whose parents were born in foreign countries and were representative of a number of Latin as well as other immigrant stocks, we feel assured that it is likely that similar high relationships between weight and bony dimensions would prevail in Porto Rican children. These relationships held in a group composed entirely of Italian immigrant stocks, although these children of Italian parentage were, like the Porto Ricans, generally smaller in all bony dimensions. Although the similarity of the height-weight findings in Porto Rican children is not regarded as evidence of the relationships between weight and bony dimensions, the fact that the findings are in harmony with this assumption is important.

The average heights reported by Bary are in general agreement with our findings. From the Standard Differences presented in Table 1 we may also see in what dimensions the difference is greater or less among 10-year-olds. The average Porto Rican children are below the averages of continental children to a greater degree in height, hips, and shoulder dimensions than in the two chest dimensions. Chest depth shows the least difference from continental children of any of the skeletal measurements. Although we are not yet prepared to offer an explanation for the relatively larger chest depth of the Porto Rican children, the difference is so well defined that it should be noted with a view to determining its significance or the usefulness of this measurement as a possible sign of growth deficiency.

We have some basis for believing that bony dimensions are influenced by genetic factors from an unpublished analysis of the continental United States data from the School Health Study of the

American Child Health Association. We found there that native born 11-year-old boys in the continental United States who are siblings of parents born in Italy have smaller height, bisacromial, chest breadth and hip dimensions than the average native born white continental United States boys, but their average chest depth is slightly larger, and native born 11-year-old girls who are siblings of parents born in Italy have smaller height and chest breadth dimensions but the average chest depth and hip dimensions are slightly larger than the average native born white continental United States girls. It appears reasonable that this difference in Italian children may be due to a genetic influence, and a similar genetic factor may be the cause of the small size of Porto Rican children.

Although within the limits of this study it is impossible to say whether or not the dimensions of the bony framework of Porto Rican children are smaller than those of continental children because of genetic influences, we can approach the problem further to determine what the differences may be apart from the bony framework and what other factors are associated with the growth of Porto Rican children.

A COMPARISON OF NUTRITIONAL STATUS INDICES OF PORTO RICAN CHILDREN WITH THOSE OF CHILDREN OF CONTINENTAL UNITED STATES

The research of the American Child Health Association has presented an analysis of physical measurements and their relation to clinical ratings of nutritional status by qualified pediatricians. This study provides a basis for regarding arm girth and calf girth as indices of the size of the general musculature of the school age child when these measurements are compared with the usual or expected arm girths and calf girths of children of the same bony dimensions. We, therefore, interpret such a use of arm and calf girth measurements as factors indicative of nutritional status.

A retarded skeletal growth may be one manifestation of a prolonged exposure to deficient diet or to disease conditions. However, the musculature may be deficient although the skeletal growth has been normal. An index of musculature should be compared with the usual musculature of children of the same kind of skeletal build because musculature and skeletal growth are correlated within a twelve month age group. As height and hip and chest dimensions vary in different proportions in different children and each of these dimensions influences the growth of the musculature in different degrees, an index of muscu-

lature may be described most accurately when it is compared with children of the same height, same hip dimensions and the same chest breadth and chest depth dimensions. Departures from the average arm girth and calf girth of children of the given four skeletal dimensions, we have termed *residuals* and have regarded them as indices of muscular development. We have, therefore, a basis for comparing Porto Rican children with continental United States children of the same bony build, or comparisons may be made in muscular development of different groupings of Porto Rican children. Muscular development apart from the skeletal build, we believe, manifests the results of nutritional conditions that probably are recent or of short term duration rather than only those more prolonged influences that may be associated with bony growth.

Another index of nutritional status that has been proposed is the amount of subcutaneous tissue, which is indicative of adiposity. The caliper measurement of subcutaneous tissue over the biceps has been found to be a reliable index of subcutaneous tissue over the back, the chest, the abdomen and other parts of the body. This finding resulted from unpublished research of the School Health Study of the American Child Health Association. As the amount of subcutaneous tissue is also influenced by the skeletal build of the child, we use the departures from the average of subcutaneous tissue over the biceps for a given skeletal build as our measure. This difference from the average subcutaneous tissue (residuals) provides a measure which may be affected by nutritional conditions that are not dependent upon bony growth changes. The two indices of nutritional status (the index of musculature and of adiposity) are used separately in order to consider two important aspects of nutritional status that should be interpreted apart from their relationship to skeletal build.

The average arm girths of 10-year-old boys of continental United States were compared with the average arm girths of Porto Rican 10-year-old boys of the same height, hip and chest dimensions, and we found the continental United States boys have larger arm girths than their peers who live under Porto Rican conditions. This comparison was made in two ways: (1) The actual average arm girth from the American Child Health Association sample of continental 10-year-old boys was compared with the expected arm girths of their Porto Rican peers of the same bony dimensions; (2) the actual average arm girths of our sample of Porto Rican boys was compared with the expected arm girths of continental United States peers of the same bony dimensions.

The regression equation derived from the intercorrelations of the anthropometric traits provided the formula for computing the expected arm girths of both the Porto Rican and the United States children.

The first formula to obtain the expected arm girth of Porto Rican boys involved the regression equation for Porto Rican boys with bony dimensions like the average continental boys. This expected arm girth of Porto Rican boys may then be compared with the average arm girths of their skeletal peers who have lived under the conditions of continental United States. This method was used to compute the expected arm girth of both boys and girls of Race 0 and Race 1 groups, and in each case we found that the average arm girths of children born in continental United States were larger than those of their skeletal peers of Porto Rico. A similar comparison between the average amount of subcutaneous tissue over the biceps in continental children and the expected subcutaneous tissue in Porto Ricans showed the tendency in favor of the continental children.

The logic of this comparison might be stated as follows:

If we select from the Porto Rican data all children whose bony dimensions are the same as the average continental United States child, then the average arm girth and amount of subcutaneous tissue of such Porto Rican children would be less than the arm girth and amount of subcutaneous tissue of the average continental child.

Table 3 shows these differences.

TABLE 3

Average Arm Girths and Subcutaneous Tissue in 10-year-old Children of Continental United States Compared with Expected Arm Girths and Subcutaneous Tissue of Porto Rican Children of Same Age, Sex and Bony Dimensions

	AVERAGE FOR CONTINENTAL UNITED STATES	EXPECTED FOR PEERS OF PORTO RICO	RACE	DIFFERENCES OR "RESIDUALS"
Arm Girths				
Boys	38.77	38.26	0	.51
Boys	38.77	37.68	1	1.09
Girls	38.87	38.66	0	.21
Girls	38.87	37.98	1	.89
Subcutaneous Tissue over Biceps				
Boys	25.82	24.69	0	1.13
Boys	25.82	23.51	1	2.31
Girls	29.65	27.70	0	1.95
Girls	29.65	26.43	1	3.22

The arm girths are measured in centimeters and are the combined girths of the upper arm flexed and relaxed. Although these differences do not appear large, it must be remembered that the variability is not great when arm girths are considered within the range of cases of the same skeletal dimensions. The variability (standard deviation) of arm girths of Porto Rican boys of the same bony dimensions is 2.04 for Race 0, and 1.74 for Race 1. For girls the variability is 2.10 for Race 0 and 2.06 for Race 1. The variability of subcutaneous tissue over the biceps is 2.58 for boys, Race 0, and 2.43 for Race 1, and for girls Race 0 is 3.08, and for girls Race 1, is 2.76. As all these measurements were carefully checked as to accuracy by computing the objectivity coefficients (correlations of measurements between the anthropometrists), we are assured that the measurements are sufficiently objective to allow no such differences to occur by chance errors in technique. The adequacy of the sampling is discussed in the Appendix of this report.

Another way of expressing the tendency for Porto Rico children to have smaller arm girths and smaller amounts of subcutaneous tissue than the average of continental United States children of the same body build, is shown by the prediction as to frequency of occurrence in a thousand children. The number of Porto Ricans in one thousand who are smaller in arm girth than their peers in continental United States for different race and sex groups is given below:

GROUP	NUMBER IN ONE THOUSAND
Boys—Race 0	600
Boys—Race 1	735
Girls—Race 0	539
Girls—Race 1	666

The number in one thousand who have a smaller amount of subcutaneous tissue for the same groups is given below:

GROUP	NUMBER IN ONE THOUSAND
Boys—Race 0	670
Boys—Race 1	829
Girls—Race 0	736
Girls—Race 1	879

The second comparison is the converse of the above and gives further emphasis to the significance of the larger measurements found in the average continental United States children. In this further com-

parison we find that the actual average arm girths and subcutaneous tissue of our sample of Porto Rican children is less than the expected arm girths of continental United States peers of the same bony dimensions. The formulae for determining the expected dimensions of the continental children are based on the regression equations for continental children with bony dimensions like the average Porto Rican child. This method determines the arm girth and subcutaneous tissue that would be expected if we had selected from the continental data all the children with bony dimensions that are the same as the average Porto Rican child.

The average arm girths and average subcutaneous tissue of Porto Rican children then can be compared with those of their peers in continental United States and Table 4 shows these differences.

TABLE 4

Average Arm Girths and Subcutaneous Tissue in 10-year-old Children of Porto Rico Compared with Expected Arm Girths and Subcutaneous Tissue of Continental United States Children of Same Age, Sex and Bony Dimensions

	AVERAGE FOR PORTO RICANS	RACE	EXPECTED FOR PEERS OF CONTINENTAL UNITED STATES	DIFFERENCES OR "RESIDUALS"
Arm Girths				
Boys	34.53	0	35.27	— .74
Boys	34.01	1	34.76	— .75
Girls	35.49	0	36.47	— .98
Girls	34.82	1	36.04	—1.22
Subcutaneous Tissue over Biceps				
Boys	23.01	0	23.44	— .43
Boys	22.57	1	23.01	— .44
Girls	26.15	0	28.92	—2.77
Girls	25.24	1	28.56	—3.32

As all these differences (residuals), are negative, we have assurance that the Porto Rican children are smaller than continental children in these two aspects of nutritional status. The prediction as to the number

of continental children in one thousand who are smaller in arm girth than their peers in Porto Rico for different race and sex groups is given below:

GROUP	NUMBER IN ONE THOUSAND
Boys—Race 0	390
Boys—Race 1	390
Girls—Race 0	352
Girls—Race 1	306

The number in one thousand who have a smaller amount of subcutaneous tissue for these same groups is given below:

GROUP	NUMBER IN ONE THOUSAND
Boys—Race 0	445
Boys—Race 1	445
Girls—Race 0	225
Girls—Race 1	180

With one assumption we might conclude that Porto Rican children are deficient in the two aspects of nutritional status considered by us. This assumption is that a Porto Rican child of the same age, sex and bony dimensions should, on the average, be expected to have arm girth and subcutaneous tissue like his peers in continental United States. Our knowledge does not justify our claiming that climate and nativity stock influences are negligible, or that all the differences found between Porto Rican and continental children are the results of the differences in dietary and disease conditions.

An important gap in our knowledge is whether musculature and subcutaneous tissue are so influenced by the tropical climate that normal growth and vigor are better adapted when smaller musculature and less subcutaneous fat prevail in Porto Rican children than are common to their peers in continental United States. Animal experiments indicate that excessive sunlight may have a retarding effect upon growth, but we know of no reason for assuming that such exposure to sunlight is common to the Porto Rican child. In the absence of scientific evidence regarding the effect of climate and genetic influences upon the musculature and subcutaneous fat of Porto Rican children, we feel justified in considering what is known regarding disease and dietary conditions

as possible and reasonable explanations of these differences between Porto Rican and continental children.

Our survey of dietary conditions, as well as those of others, indicates a high probability that the diet prevailing in Porto Rican homes is generally poorer according to accepted standards than the diet consumed by continental children. Studies of intestinal parasitic infestation, malaria, and other diseases, indicate that disease conditions are undoubtedly worse in Porto Rico than among children of our continental sample. Both clinical experience and experimental science would favor the view that diet and disease may cause growth and developmental deficiencies. Similar comparisons of children from Spain or some other Spanish country not exposed to the same climatic, dietary, or disease conditions might throw important light upon the problem.

SOCIO-ECONOMIC STATUS AND ANTHROPOMETRIC TRAITS

The significance of smaller physical measurements of Porto Rican children than of continental children was further studied by determining the relationships to certain socio-economic factors. Our hypothesis for this inquiry was that the children who have had the advantage of certain socio-economic environments may have had more freedom from disease and better diets than others not so privileged, and therefore, if disease and diet influence the growth of Porto Rican children, it would be manifest in the relation of socio-economic factors to anthropometric traits.

Other hygienic factors may be operating to accentuate or to interfere with these relationships, but without the fundamental research necessary to provide the basis for a more direct approach to our problem, these relationships were studied to test our hypothesis in the interest of future research and to determine such tendencies as might have a bearing upon public health policies.

As no socio-economic measurements applicable to Porto Rican conditions were available, we used the following distinctions, which are generally definite and fairly accurate but, no doubt, limited in their selection of groups associated with dietary and disease conditions.

Urban and rural distinctions are important because of the known difference between these groups with respect to intestinal parasitic infestations as well as possible differences in diet. Urban cases were divided into owners and renters, and considered separately. Owners

were classified as to tax valuation of their property as reported in the local tax office. Renters were classified as to the rent paid per month. Rural cases were divided into two groups according to whether or not they were in the "agregado" class, and these groups were considered separately. As the "agregado" families live on such a precarious economic level, dependent upon uncertain wages and the good will and economic status of the landowner, they are generally regarded as a very poor group. Further economic distinctions within these classes were attempted as follows:

Rural, "Not Agregado"

1. Owns a large farm, or a large store.
2. Rents a large farm, or a large store.
3. Owns a small farm, or a small store, or a truck.
4. Rents a small farm, or a small store, or a truck.
5. Vendor, or crop-sharer—owns *house, cow* and *horse.*
6. Owns two of the above italicized.
7. Owns one of the above italicized.
8. Owns none of the above italicized.

Rural "Agregado"

1. "Agregado," owns *house, cow* and *horse.*
2. Owns two of the above italicized.
3. Owns one of the above italicized.
4. Owns none of the above italicized.
5. Destitute.

The number of rooms in the house occupied by each child was regarded as another socio-economic distinction which was applicable to both the urban and rural groups. This distinction assumed that children from homes with a larger number of rooms were generally of a higher socio-economic status than children from homes with a smaller number of rooms.

The average number of persons per room was also regarded as an index of socio-economic status applicable to both urban and rural groups. Children from homes with less crowding as shown by average number of persons per room were regarded as generally of a higher socio-economic status than children from the more crowded households.

The number of persons in the house was regarded as an index of the size of the family which might have some significance as a socio-economic distinction and was therefore considered.

The grade which the child had reached in school was also used as an index of socio-economic status. Although school retardation may be

caused by other factors than intelligence, studies in continental United States have shown that intelligence of children is correlated with economic status of parents. Lack of early school opportunity may be expected to be associated with limited socio-economic advantages, and therefore we might anticipate that children of the same age (10 years or over and less than 11 years) in the lower grades are more frequently associated with poorer conditions than children in the more advanced grades.

The intercorrelations of these socio-economic factors with four anthropometric traits were computed and are on file in sixteen tables in the office of the American Child Health Association for reference. The following tables of correlations are selected from them as of particular interest to our problem.

TABLE 5

Relation of Monthly House Rent to Four Anthropometric Traits
10-year-old Urban Children

CORRELATION OF MONTHLY HOUSE RENT WITH:	BOYS		GIRLS	
	Race 0	Race 1	Race 0	Race 1
Height	.51	.48	.38	.28
Hip Width	.31	.48	.39	.35
Arm Girth	.41	.47	.45	.31
Subcutaneous Tissue over Biceps	.24	.35	.34	.32

The urban Porto Rican children from homes where the higher rents are paid show a tendency to be taller, have greater hip width, larger arm girth and greater amounts of subcutaneous tissue over the biceps than children from homes where lower rents are paid.

The fact that all these correlations are positive and vary from .24 to .51 indicates clearly the tendency. This relationship may be due to a genetic influence or the conditions for growth may be better in the homes where the higher rents are paid. Parents who are larger in these anthropometric traits may generally be in the more privileged economic groups and their children may inherit the larger dimensions. However, our data make clear that if these anthropometric traits are susceptible to disease and dietary influences as we believe likely, the range of differences in rent paid is sufficient to assume that they are representative of socio-economic differences that may be associated with extreme dietary and disease conditions. The data show among the homes paying the higher rents cases paying as high as $70, $80 and over $125 per month

rent, while there are also numerous children from homes where the parents pay only $1, $2, $3 and $5 per month rent. Some pay no rent. The latter are probably servants in urban families of the "agregado" class. It stands to reason that children from homes paying from $70 to $100 per month rent live under conditions more conducive to freedom from disease and on the average have a more liberal diet than children from homes where the parents probably are unable to pay more than from $1 to $5 per month rent. The evidence points then to the conclusion that the socio-economic status of urban children as indicated by rent must be associated with some factor which influences the growth of Porto Rican children in these four traits.

The relation of the socio-economic status of property owners to the anthropometric traits of the children was studied by determining the correlation between the tax valuation of the property owned by the parents and the anthropometric traits of the children.

TABLE 6

Relation of Property Valuation to Four Anthropometric Traits 10-year-old Urban Children

CORRELATION OF PROPERTY VALUATION WITH:	BOYS		GIRLS	
	Race 0	Race 1	Race 0	Race 1
Height	.21	.27	.10	—.03
Hip Width	.31	—.06	.06	.05
Arm Girth	.49	.18	.10	—.05
Subcutaneous Tissue over Biceps	.34	.13	.21	.06

Table 6 shows no such consistent correlations between socio-economic status as indicated by the tax valuation of the property and anthropometric traits as was shown by the relation of the monthly house rent and anthropometric traits. It seems quite possible that the tax valuation of the property of these children from families of urban home owners does not indicate important differences in their socio-economic status; or it may be that among urban home owners the variations in the socio-economic status is not great enough to manifest any effect upon the growth of the children.

The urban children from homes where there are fewer persons per room have a tendency to be taller, have greater hip width, larger arm girth and greater amounts of subcutaneous tissue over the biceps than children from the more crowded homes where the average number of persons per room is larger.

TABLE 7

Relation of Number of Persons per Room to Four Anthropometric Traits
10-year-old Urban Children

CORRELATION OF PERSONS PER ROOM WITH:	OWNERS				RENTERS			
	Boys		Girls		Boys		Girls	
	Race 0	Race 1	Race 0	Race 1	Race 0	Race 1	Race 0	Race 1
Height	—.27	—.33	—.23	—.21	—.42	—.27	—.44	—.08
Hip Width	—.29	—.39	—.23	—.09	—.23	—.31	—.22	—.20
Arm Girth	—.31	—.26	—.21	—.03	—.40	—.31	—.29	—.18
Subcutaneous Tissue over Biceps...	—.20	—.19	—.22	—.11	—.27	—.09	—.24	—.30

It will be noted that all of these correlations are negative and over three-fourths of them are between —.20 and —.44. The tendency is therefore definitely consistent with the interpretation that economic status as shown by the crowding of the home is associated with a larger growth of the children.

TABLE 8

Relation of Number of Rooms in the House to Four Anthropometric Traits
10-year-old Urban Children

CORRELATION OF ROOMS IN HOUSE WITH:	OWNERS				RENTERS			
	Boys		Girls		Boys		Girls	
	Race 0	Race 1	Race 0	Race 1	Race 0	Race 1	Race 0	Race 1
Height	.41	.55	.27	.14	.46	.42	.41	.20
Hip Width	.37	.45	.20	.09	.33	.51	.34	.24
Arm Girth	.48	.42	.16	—.03	.45	.50	.42	.16
Subcutaneous Tissue over Biceps...	.42	.19	.14	.11	.30	.38	.31	.28

The urban children from the homes with the larger number of rooms in the house have a tendency to be taller, have greater hip width, larger arm girths and greater amounts of subcutaneous tissue over the biceps than children from the smaller homes with fewer rooms.

The size of the family as indicated by the number of persons in the house is not related to the size of the anthropometric traits.

The urban children who are in the more advanced grades in school for their age show a tendency to be taller, to have greater hip width, larger arm girths and more subcutaneous tissue over the biceps than children who are more backward in their school grade.

TABLE 9

Relation of Number of Persons in the House to Four Anthropometric Traits 10-year-old Urban Children

CORRELATION OF PERSONS IN HOUSE WITH:	OWNERS				RENTERS			
	Boys		Girls		Boys		Girls	
	Race 0	Race 1	Race 0	Race 1	Race 0	Race 1	Race 0	Race 1
Height	.19	.00	—.00	—.14	.46	.42	.41	.20
Hip Width	.13	—.10	—.05	—.00	.33	.51	.34	.24
Arm Girth	.13	—.14	—.05	—.08	.45	.50	.42	.16
Subcutaneous Tissue over Biceps...	.11	—.10	—.14	—.05	.30	.38	.31	.28

Although these relationships are generally consistent with our other correlations with socio-economic indices, we should recognize the possibility that schools may have a tendency to push ahead the larger children into more advanced grades. On the other hand, it appears reasonable to expect that children of the same age who are in the more advanced grades in school would generally come from the homes of the better socio-economic classes. With this assumption our correlation indicates another bit of evidence that the socio-economic status of urban children is associated with some factor which influences the growth of Porto Rican children in these four traits.

TABLE 10

Relation of Child's School Grade to Four Anthropometric Traits 10-year-old Urban Children

CORRELATION OF CHILD'S GRADE WITH:	OWNERS				RENTERS			
	Boys		Girls		Boys		Girls	
	Race 0	Race 1	Race 0	Race 1	Race 0	Race 1	Race 0	Race 1
Height	.39	.62	.30	.36	.55	.38	.50	.39
Hip Width	.31	.39	.23	.35	.34	.41	.35	.33
Arm Girth	.32	.39	.21	.30	.40	.32	.32	.28
Subcutaneous Tissue over Biceps...	.23	—.11	.20	.15	.18	.23	.22	.23

All these correlations except for four low relationships point to a consistent tendency for children from homes of the better socio-economic status to have larger arm girths in proportion to their skeletal build than children of the poorer classes. As already indicated, arm girth residuals are regarded as one index of musculature and therefore of nutritional status, because they are the difference between the ex-

TABLE 11

Relation of Certain Socio-Economic Forces to Arm Girth Residuals
10-year-old Urban Children, Race 0

CORRELATION OF ARM GIRTH RESIDUALS WITH:	BOYS		GIRLS	
	Owners	Renters	Owners	Renters
Property Valuation	.35	....	.15	....
Rent Paid	....	.21	....	.22
Rooms in House.....	.36	.24	.04	.24
Persons per Room.....	—.19	—.28	—.06	—.15

pected arm girth for any combination of individual bony dimensions and the actual arm girth. We interpret these correlations, therefore, as suggesting some general tendency for children from the better homes as indicated by our socio-economic factors to have larger musculature and probably better nutritional status than children from the poorer homes.

Rural children show no such consistent tendency for larger physical development to be associated with the more privileged socio-economic status as is found among the urban children. All the intercorrelations with our socio-economic variables were computed for rural children, both among the "agregado" and "not agregado" children. The relationships are low and such relationships as are found appear to be chance. It is quite possible that the rating scales used do not distinguish rural families in important socio-economic ways. Since we used several of the same methods of distinction that gave correlations with the urban children, we are led to associate the lack of relationships with some important differences between urban and rural children. Average number of persons per room, number of rooms in the house and grade attained by the child in school all failed to show significant relationships with anthropometric traits.

There is a similar tendency among rural children for a lack of correlation between arm girths for a given bony build (residuals) and the same socio-economic factors. A slight tendency among these correlations is in the direction of better socio-economic status associated with the larger arm girth residuals. The correlations, however, do not justify concluding more than that there is a difference between the urban and rural relations. This is shown in Table 12.

We found no significant differences in the average size of the anthropometric traits between the rural "agregado" group and the rural "not agregado" group. This is shown in Table 13.

TABLE 12

Relation of Socio-Economic Factors to Arm Girth Residuals
10-year-old Rural Children, Race 0

CORRELATION OF ARM GIRTH RESIDUALS WITH:	BOYS		GIRLS	
	Not Agregado	Agregado	Not Agregado	
Economic Rating*	—.09	—.06	.06	—.
Persons in Room.....	—.07	—.01	—.22	
Rooms in House.....	.25	.05	.22	
Child's School Grade....	.15	.09	.11	.14

* See Table, page 484. Distinctions were scored from 1 to 8 for "not ag and 1 to 5 for "agregado." Highest scores were poorest status.

TABLE 13

Comparison of Anthropometric Traits in Rural Agregado and N Agregado Children

10-year-old Children—Average Measurements

TRAITS	BOYS				GIRLS			
	Race 0		Race 1		Race 0		Pu	
	Agr.†	Not Agr.	Agr.	Not Agr.	Agr.	Not Agr.	Agr.	Ag
Height	49.11	49.70	49.22	49.45	49.46	49.48	49.30	
Hip Width	21.35	21.30	21.23	21.62	21.79	21.82	21.	
Arm Girth	33.62	32.77	32.80	33.55	33.74	34.23	34.	32.46
Subcutaneous Tissue over Biceps...	21.69	21.40	21.30	21.75	24.15	23.90	23.60	23.72

† Agr. is abbreviation for "Agregado."

We also found that the average arm girth residuals showed no consistent distinction between the "agregado" group and the "not agregado" group. This comparison is presented in Table 14.

These findings consistent with the lack of correlation between anthropometric traits and socio-economic factors show a lack of differences in the growth and physical development of rural children in socio-economic groups distinguished by us. They give support to a vi that there are no important differences in the mode of living of the various rural classes in a manner to affect the growth of the children. Life is generally primitive in rural Porto Rico and superstitious beliefs interfere with hygienic living as well as ignorance of sanitary, dietetic and other hygienic measures for health protection and promotion. It is therefore reasonable to expect that these socio-economic differences are

TABLE 14

Comparison of Arm Girth Residuals in Rural Agregado and Not Agregado Children

10-year-olds, Race 0

	BOYS		GIRLS	
	Agregado	Not Agregado	Agregado	Not Agregado
Average Arm Girth Residuals...	—.95	—2.03	—1.83	—.16

not generally associated with differences in manner of living, disease tendencies and diet among the rural people. The distinctions made with the rating scale, with the housing measurements and with the school grade may not be indicative of real socio-economic distinctions under rural Porto Rican conditions, but we favor the interpretation that both the limitations of our socio-economic distinctions and a general tendency toward unhygienic living among all rural groups contribute to the zero and low chance correlations.

In general, the correlations found between the socio-economic variables and the physical traits are not high but they are consistent except in the rural children. We find such a general tendency in favor of the children from homes of the higher economic status that it is apparent that the relationship is reliable. The difficulty of obtaining suitable socio-economic indices has probably been a considerable handicap to us in revealing the actual socio-economic influences upon the growth and development of Porto Rican children. The consistency of the tendency for children from the better homes as indicated by our various socio-economic factors to have bigger bony dimensions and larger nutritional status indices than children from poorer homes is certainly suggestive and thoroughly justifies a conclusion favoring further study to determine the effect of disease and of a more liberal diet upon the growth and development of Porto Rican children.

PRIVATE SCHOOL CHILDREN

A further indication of the effect of socio-economic influences upon the growth and development of the Porto Rican children was shown by a study of private school children who are probably representative of children from homes of the most privileged socio-economic status. The average physical measurements of the private school children were compared with the average of these traits in the public school children. The comparison is shown in Table 15.

TABLE 15

Comparison of Anthropometric Traits in Private and Public School Children

TRAIT	AVERAGE MEASUREMENTS								STANDARD DIFFERENCES			
	10-year-olds				8-year-olds				10-year-olds		8-year-olds	
	Boys		Girls		Boys		Girls					
	Private School	Public School	Private School	Public School	Private School	Public School	Private School	Public School	Boys	Girls	Boys	Girls
Height	53.3	50.3	53.0	50.7	49.1	47.0	49.4	47.2	8.7	8.6	4.6	5.4
Bisacromial	28.2	26.7	28.0	26.9	25.9	24.8	25.9	24.9	6.9	7.2	3.8	4.3
Chest Breadth	41.9	39.9	41.3	40.0	38.8	38.1	38.7	37.4	4.9	6.2	1.9	3.5
Chest Depth	30.5	30.1	30.2	29.5	29.2	28.9	28.4	27.5	1.5	2.7	0.7	3.0
Hip Width	23.1	21.9	23.9	22.5	21.3	20.2	21.8	20.7	6.2	8.1	4.6	4.8
Arm Girth	36.6	34.3	38.4	35.2	34.2	32.4	35.2	33.1	4.1	6.8	3.2	4.8
Calf Girth	26.3	24.9	27.1	25.3	24.4	23.3	25.0	23.4	4.7	6.9	3.3	5.5
Subcutaneous Tissue												
over Biceps	24.6	22.8	28.3	25.8	...	...	...	...	4.1	6.0	..	..
over Triceps	66.9	61.5	77.4	71.0	...	...	...	...	4.2	6.0	..	..

We find that the 10-year-old private school children are significantly larger than the Porto Rican public school children in all dimensions except chest depth and the 8-year-old private school children are significantly larger than the public school children in all dimensions except chest breadth and chest depth for boys. The Standard Differences are all greater than three with the exceptions mentioned and the chest depth of 8-year-old girls, so we may consider that the differences are not due to chance but would be found again in similar samples.

As skeletal growth may be affected by genetic influences apart from any nutritional effects, we sought a basis for comparing the private school children with public school children with allowance made for skeletal growth. The expected arm girth for any given bony dimensions and expected amount of subcutaneous tissue for any bony dimensions provides such a basis. To accentuate the socio-economic distinctions we compared private school children with urban children who came from homes where their parents paid a rent of from $6.00 to $10.00 per month inclusive and also children from homes paying $5.00 per month or less for rent.

This comparison is shown in Table 16.

TABLE 16

Comparison of Indices of Nutritional Status in Extreme Economic Groups
10-year-olds

ECONOMIC GROUPS OF CHILDREN	AVERAGE RESIDUALS							
	Arm Girth				Subcutaneous Tissue over Biceps			
	Boys		Girls		Boys		Girls	
	Race 0	Race 1	Race 0	Race 1	Race 0	Race 1	Race 0	Race 1
Private School ..	.40	.60	1.75	.57	1.13	.98	.69	.92
Urban Public School—Rent per month $6-$10...	—1.36	—1.34	— .32	— .20	— .95	1.21	.23	—1.08
Rent per month $5 and less.....	— .65	—1.01	—2.53	—1.44	— .04	— .59	.24	— .32

We find the average private school children in all groups have both arm girth and subcutaneous tissue greater than the expectation of public school Porto Ricans of the same bony dimensions (positive residuals). On the other hand the poorer public school children show smaller average arm girth and subcutaneous tissue less than the expected (negative

residuals) in all groups except three. This evidence seems to indicate that private school children have a definite tendency to have larger arm girths for their body build than the poorer urban children and likewise they have greater amounts of subcutaneous tissue over the biceps for their body build than the poorer urban children.

ANTHROPOMETRIC DIFFERENCES BETWEEN URBAN AND RURAL CHILDREN

In our study of socio-economic status and anthropometric traits, we have seen a difference between urban and rural children. Urban children show a relation between their anthropometric traits and most of the socio-economic factors measured by us while rural children show no such relationship. "Agregado" and "not agregado" children showed no significant differences either in gross dimensions nor in indices of musculature for a given body build. As the studies of the Insular Health Department and the Rockefeller Foundation have reported again and again that hookworm is more prevalent among rural children than among urban children, a further study of urban and rural differences appeared important.

The average physical measurements of the urban children were compared with those of rural children with the result that urban children are found to be taller; have greater hip width, larger arm girths and greater amounts of subcutaneous tissue over the biceps than rural children. These findings are shown in Table 17.

The significance of this urban and rural difference in children is shown by the Standard Difference which is greater than three for both race and sex groups and for all four dimensions except for height and hip measures of Race 1 boys. A further division into groups shows a similar consistency in favor of larger dimensions for the urban children (Table 18). Both owners and renters show larger dimensions by sex and race groups than either rural "agregado" or "not agregado" children. The consistency of all these groups supports our judgment that the sampling has been adequate to reveal true urban and rural differences.

A further evidence of the distinction between urban and rural children is shown by the differences in the average arm girth residuals of urban Race 0 boys and girls and similar measures of comparable rural children (Table 19). This comparison indicates that all of the urban groups except one have on the average arm girths larger than their rural peers with the same bony dimensions. This is shown by the fact

TABLE 17

Comparison of Anthropometric Traits in Urban and Rural Children—10-year-olds

TRAIT	AVERAGE MEASUREMENTS								STANDARD DIFFERENCES			
	Race 0				Race 1				Race 0		Race 1	
	Boys		Girls		Boys		Girls		Boys	Girls	Boys	Girls
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural				
Height	50.8	49.3	51.0	49.5	49.8	49.3	50.7	49.5	5.2	5.5	1.4	3.3
Hip Width	22.2	21.3	22.7	21.8	21.7	21.4	22.5	21.8	6.1	6.1	1.6	3.6
Arm Girth	35.0	33.3	35.3	34.0	34.2	33.0	35.2	33.8	5.9	4.5	3.3	3.4
Subcutaneous Tissue over Biceps	23.4	21.6	26.8	24.0	23.0	21.4	26.0	23.6	6.9	8.3	4.2	6.0

TABLE 18

Comparison of Anthropometric Traits in Urban and Rural Children by Socio-Economic Groups—10-year-olds

TRAIT	AVERAGE MEASUREMENTS OF BOYS							AVERAGE MEASUREMENTS OF GIRLS						
	Urban				Rural			Urban				Rural		
	Race 0		Race 1		Race 0		Race 1	Race 0		Race 1		Race 0		Race 1
	Owners	Renters	Owners	Renters	Not Agregado	Agregado	Agregado	Owners	Renters	Owners	Renters	Not Agregado	Agregado	Agregado
Height	51.2	50.2	49.7	50.0	49.7	49.1	49.2	50.8	51.4	50.3	51.6	49.5	49.5	49.4
Hip Width	22.3	21.9	21.6	21.8	21.3	21.4	21.2	22.7	22.7	22.1	23.3	21.8	21.8	21.7
Arm Girth	35.2	34.6	34.3	34.1	32.8	33.6	32.8	35.2	35.6	34.6	36.7	34.2	33.7	34.1
Subcutaneous Tissue over Biceps	23.7	22.9	23.0	23.1	21.4	21.7	21.8	26.9	26.8	25.6	26.8	23.9	24.2	23.6

TABLE 19

Comparison of Average Arm Girth Residuals of Urban and Rural Porto Rican Children—Race 0, Age 10

	URBAN			
	Owners		Renters	
	Boys	Girls	Boys	Girls
Average Arm Girth Residuals	+ .37	—1.08	+ .35	+ .46

	RURAL			
	Not Agregado		Agregado	
	Boys	Girls	Boys	Girls
Average Arm Girth Residuals	—2.03	— .16	— .95	—1.83

that all of the urban residuals are positive except one and all the rural residuals are negative. Positive residuals mean above the average and minus residuals mean below average. If we are to interpret the departures from the average arm girths for a given bony build (residuals) as an index of nutritional status, we may conclude that the nutritional status of the urban children has a tendency to be superior to that of the rural children.

SUMMARY

The evidence that some factor associated with socio-economic status probably influences the growth and development of Porto Rican children is shown by comparison of Porto Rican and continental United States children, by correlations between physical measurement of Porto Rican children with socio-economic indices, and by urban and rural differences in physical traits.

The following are the more important findings:

1. Porto Rican children are smaller in all anthropometric traits than children in continental United States. Tables 1 and 2.
2. The index of musculature as shown by the expected arm girth of Porto Rican children is less than the average arm girth of continental United States children of the same bony dimensions and the same age and sex. Table 3. Also the average arm girth of Porto Rican children is smaller than the expected arm girth of continental United States children of the same bony dimensions, age and sex. Table 4.

3. The index of adipose tissue in the skin as shown by the expected amounts of subcutaneous tissue over the biceps of Porto Rican children is less than the average measurement of subcutaneous tissue over the biceps of continental United States children of the same bony dimensions and the same age and sex. Table 3. Also the average amount of subcutaneous tissue over the biceps of Porto Rican children is smaller than the expected amount of subcutaneous tissue over the biceps of continental United States children of the same bony dimensions, age and sex. Table 4.

4. The urban Porto Rican children from homes where the higher rents are paid show a tendency to be taller, have greater hip width, larger arm girth and greater amount of subcutaneous tissue over the biceps than children from homes where lower rents are paid. Table 5.

5. The urban children from homes where there are fewer persons per room have a tendency to be taller, have greater hip width, larger arm girth and greater amount of subcutaneous tissue over the biceps than children from the more crowded homes where the average number of persons per room is larger. Table 7.

6. The urban children from the homes with the larger number of rooms in the house have a tendency to be taller, have greater hip width, larger arm girth and greater amount of subcutaneous tissue over the biceps than children from the smaller homes with fewer rooms. Table 8.

7. The urban children who are in the more advanced grades in school for their age show a tendency to be taller, to have greater hip width, larger arm girth and more subcutaneous tissue over the biceps than children who are more backward in their school grade. Table 10.

8. The urban children with the larger arm girths for a given body build have a tendency to be found in homes where the tax valuation of the property is greatest, where the highest rents are paid, where the homes have the largest number of rooms and where there is the least crowding as shown by the average number of persons per room. Table 11.

9. Private school children have a definite tendency to have a greater physical development in several anthropometric traits including skeletal dimensions than the average public school Porto Rican children of the same age. Table 15.

10. Private school children have a definite tendency to have larger arm girths for their body build than the poorer urban children and likewise they have greater amounts of subcutaneous tissue over the biceps than the poorer urban children. Table 16.
11. Urban children are taller, have greater hip width, larger arm girth and greater amount of subcutaneous tissue over the biceps than rural children. Tables 17 and 18.
12. Rural children show no such consistent tendency for larger physical development to be associated with the more privileged socio-economic status as is found among the urban children. Tables 12, 13 and 14.
13. Urban children have larger arm girths for any given combination of bony dimensions (residuals) than rural children. Table 19.

RÉSUMÉ

This analysis has been conducted on the hypothesis that diet and disease may or may not be causal factors affecting the physical measurements of Porto Rican children. Such an hypothesis must take cognizance of the principle that correlations are not proof of cause and effect relationships. However, with such objective measurements of children as have been used in this study, the relationships must indicate either that cause and effect operate in one direction or the other or that the related factors are associated with one or more causal factors.

The evidence among Porto Rican children of smaller skeletal growth, musculature and subcutaneous tissue than among continental children, of similarly smaller dimensions among the poorer socio-economic groups in Porto Rico than among the more privileged groups and also among the rural as compared with the urban children is all consistent with the hypothesis that these physical measurements of Porto Rican children are affected by some factor associated with the socio-economic distinctions used by us. The evidence that disease is associated with these socio-economic distinctions is, we believe, so apparent as to require no further demonstration than reference to the studies of the Insular Health Department and the Rockefeller Foundation. The observations on the probable food consumption are sufficiently impressive to justify the assumption that good and poor diets are similarly associated with our socio-economic measurements. It is therefore reasonable to conclude that diet and disease may be so related to the socio-economic measurements used that any causal influence of diet and disease upon growth

and development would be reflected in the correlation of the socio-economic variables with the variations in the physical measurements.

The relationships found between the socio-economic distinctions and the physical measurements then are considered as contributory to the problem of whether Porto Rican children suffer manifestations of deficiency in growth and development. The evidence does not permit us to rule out climatic or genetic influences as possible explanations of our findings but sufficient support is given to the hypothesis concerning the effect of diet and disease upon Porto Rican children to justify the further trial of medical and sanitary means of controlling intestinal parasitic infestation and of educational, economic, and agricultural services for the improvement of diets. Both clinical experience and experimental evidence favor service directed at these disease and dietary problems on other grounds than their possible effect on the growth of the children. It is also reasonable to expect that an effect of disease and diet upon the growth and development of children is an extreme manifestation and the removal of this influence would be beneficial to the strength and vigor of the children in many ways.

More definite evidence of the effect of diet and disease upon Porto Rican children might be obtained by an experimental approach. Intestinal parasitic infestation might be measured for the children of experimental and control groups. Through the assistance rendered by the Rockefeller and Health Department Laboratories, we attempted to distinguish children with heavy parasitic infestation from those with little or no infestation according to the differences in egg counts by the Stoll dilution method but this experience confirmed by the previous work of Payne and others indicated that several fecal specimens with egg counts would be necessary for reliable distinctions in individuals. The extreme conditions of intestinal parasitic infestation and inadequate diet among Porto Rican children as well as the disease control facilities of the District Health Units and the school lunches for supplementing the children's diet offer extraordinarily valuable experimental situations to study the effect of disease and diet upon the growth and development of children. The data of this report are regarded as basic material essential for such research.

The author wishes to acknowledge his indebtedness to the Director, George T. Palmer, D. P. H., and to the Staff of the Research Division of the American Child Health Association. In the planning and analysis, Raymond Franzen, Ph. D., gave invaluable aid and advice, while the supervision of the statistical work was undertaken by Mahew Derryberry who also contributed important advice and criticisms.

APPENDIX

THE CHILDREN MEASURED

Conclusions about Porto Rican children necessarily involve such a sampling of children as may be known to be truly representative of all children on the island or representative of such a part of the child population as may be definitely defined. Our sampling is believed to be fairly representative of all white urban school children and the white rural school population of the hill country or exclusive of the coastal plains. The coastal plain population was excluded because this area includes most of the Negro population and the racial influence was a complicating factor; and because the hill country population more nearly represents the varied socio-economic situations than the coastal plains where agriculture is almost wholly industrialized. The distribution of the rural schools is shown in Figure 1 (page 506). More definite location of the schools is shown by the list of schools by the municipality and Barrio in the table on pages 503-505.

The random character of the sampling of each school is shown by the fact that the urban schools included all 10-year-old children attending and the rural schools included all the 8- and 10-year-old children. This method insured a representative sample of all socio-economic classes attending schools. As rural children have some tendency to enter school at an older age and leave school at an earlier age, both 8- and 10-year-olds were selected to insure the most representative sample of rural children.

Socio-Economic Distinctions

Any hypothesis regarding the influence of diet, habits, behavior or disease upon the nutritional condition of children should not overlook the likelihood that these factors may be associated to some extent at least with socio-economic differences. In the absence of definite knowledge of the relationship between these environmental influences and the complexity of socio-economic factors, we attempted to determine as accurately as possible such socio-economic distinctions as could be made without special research for the development of socio-economic measurements. It appears appropriate to assume that all the 10-year-old children of a school are a representative sample of school attending children of an urban school district, except for the children in private schools, who are measured separately, and the interference of sickness and poverty. Incomplete attendance probably is a random factor. We assume then that the children missed by our selection in urban schools would probably represent less than the average opportunity.

Children from homes where the parents owned their home were differentiated from home renters and the data from such were handled separately because we were unable within the scope of this study to interpret the relative socio-economic variations among renters on the same basis as the home owners. The tax valuation of the property as recorded in the assessor's office was used as one method of differentiating socio-economic levels in the home owning class. Mortgages no doubt influenced the relative status by this method but the wide variation in property valuation was assumed as representing to a considerable degree socio-

economic distinctions of this group. Likewise, the variation in the amount paid per month for rent by parents, though not wholly representative of the distinctions desired, did represent distinctions of importance. The character of the home conditions was also assumed to be reflected by the amount of crowding in the home as shown by the number of persons per room, as well as the size of the home as reflected by the number of rooms in the house. As there is evidence from studies in the United States that the higher socio-economic status of parents is associated with the higher intelligence of the children, we assumed that the 10-year-old children in the more advanced grade in school generally came from the homes of the higher socio-economic status.

For the rural children we found that the Porto Rican tradition has drawn rather sharply defined social distinctions between the "agregado" class, the "medianero" class and those owning or renting a farm or home in the rural districts. The "agregado" group represents an underprivileged class whose parents are "squatters" on a property. They are allowed to build their own house or it is furnished to them by the property owner and they are allowed to remain there at the will of the property owner. The property owner demands usually in return that the "squatter" work for him for wages as he has need for laborers. Many property owners take a paternalistic interest in the "agregado" families on their property supplying them with food from the farm at times of unemployment and some even provide for medical care. The "agregado" family is often in debt, cannot move even when out of debt without giving up his house and many exist on a level of poverty and impoverishment unusual in the United States.

The "medianero" families generally have greater opportunity than the "agregado" families. These are the crop-sharers working a few acres on shares with the owners. The families of the "ventorrillo" or vendor group were classified with the "medianero" class. The Spanish term "ventorrillo" is applied to the men operating a push cart or a small roadside stand. Although they are generally fairly independent, the number of articles they have to sell is usually so limited that their income is very low. They are regarded as less poverty stricken than the "agregado" class because their work is not so seasonal nor so dependent upon a precarious wage. Their sales are usually limited to a few bananas or other fruits or vegetables.

We attempted to further classify these groups as to their ownership of a house, a cow, and a horse; then as to ownership of any two of these; ownership of any one and those owning none. For the rural families of better socio-economic status than the "medianero" or "agregado" class, we distinguished those owning a "finca grande" or large farm (more than 20 cuerdas) or those merchants owning a large store. Those families renting a "finca grande" or a large store were distinguished as the next most fortunate class. The ownership of a "finca pequena" or small farm (20 cuerdas or less) was regarded as a suitable third classification. As families owning a motor truck are able to obtain considerable business of transportation of supplies and food products, they were also included in the third classification. The renting of a small farm, small store or truck was classified as the fourth group.

These classifications were used by Spanish-speaking interviewers who determined the class and other socio-economic information from the child, the teacher, or the tax assessor for each child measured. The following table shows the thirteen rural class groups described and the frequency found by our interviewers.

Rural Socio-Economic Classifications and Incidence as Reported by School Children

		NUMBER OF CASES	
1.	Owns a large farm, or large store	33	234
2.	Rents a large farm, or large store	22	
3.	Owns a small farm, or small store, or truck	179	
4.	Rents a small farm, or small store, or truck	33	220
5.	Vendor, or crop-sharer—Owns *house, cow* and *horse*	82	
6.	Owns *two* of the above italicized	43	
7.	Owns *one* of the above italicized	34	
8.	Owns *none* of the above italicized	28	
9.	"Agregado"—Owns *house, cow* and *horse*	57	718
10.	Owns *two* of the above italicized	113	
11.	Owns *one* of the above italicized	208	
12.	Owns *none* of the above italicized	309	
13.	Destitute	31	
		1172	

As probably not much more than one-half of the rural children have school opportunity * and it is likely that school attendants generally have more economic opportunity than non-school attendants, we may safely assume that our figures do not in any way exaggerate the proportion of children in the less privileged groups.

In order to test the adequacy of the rural sample of school children in the areas studied, we divided the data in half by selecting schools from alternately different municipalities in the different regions of the Island and then computed the percentages of children by socio-economic classes in each of the two samples. The following list of schools by municipality and Barrio indicates the distribution of these two groups of rural schools as well as the distribution of the whole sample:

Sample ▲

KEY NUMBER	MUNICIPALITY	BARRIO	SCHOOL NUMBER
2R-7	Caguas	Rio Canas	—
2R-8	Caguas	Rio Canas	—
2R-9	Caguas	Rio Canas	—

* The 1920 United States Census reports 16 per cent of the 5- and 6-year-old children attending school and 54.3 per cent of the children between 7 and 13 years inclusive. Also 61.6 per cent of the rural population 10 years old and over were illiterate.

Sample ▲

NUMBER KEY	MUNICIPALITY	BARRIO	SCHOOL NUMBER
2R-10	Caguas	Rio Canas	—
4R-1	Las Piedras	Boqueron	207
4R-2	Las Piedras	El Rio	203
4R-3	Las Piedras	El Rio	202
5R-1	San Lorenzo	Cayaguas	202
5R-2	San Lorenzo	Quebrada Honda	218
			219
5R-3	San Lorenzo	Florida	210
5R-4	San Lorenzo	Florida	211
7R-2	Corozal	Padilla	215
			222
			228
7R-3	Corozal	Cibuco	205
7R-4	Corozal	Cuchillas	203
			209
10R-2	Comerio	Rio Honda	220
10R-3	Comerio	Arriba Abajo	221
10R-4	Comerio	Arriba Abajo	222
10R-5	Comerio	Arriba Abajo	223
20R-1	Utuado	Vivi Abajo	258
			259
			260
			261
20R-3	Utuado	Rio Abajo	235
			236
20R-4	Utuado	Salto Arriba	246
			247
			248
20R-5	Utuado	Caonillas Arriba	219
			220
			221
24R-1	Maricao	Montoso	202
			203
24R-2	Las Marias	Naranjales	208
24R-2	Las Marias	Palma Escrita	209
			213

Sample ●

KEY NUMBER	MUNICIPALITY	BARRIO	SCHOOL NUMBER
3R-1	Juncos	Guraba Arriba	211
			214
			215
3R-2	Juncos	Ceiba Norte	209
6R-2	Toa Alta	Quebrada Arenas	206
			207
			208
8R-1	Morovis	Monte Llano	—
9R-1	Ciales	Cialitos	227
9R-2	Ciales	Pesas	228
9R-3	Ciales	Pesas	229
9R-4	Ciales	Pesas	231
9R-5	Ciales	Pesas	232
11R-1	Barranquitas	Honduras	209
			210
			211
11R-2	Barranquitas	Barrancas	202
			203
11R-3	Barranquitas	Palo Hincado	217
			218
			219
11R-4	Aibonito	Helechal	214
			215
			216
13R-2	Adjuntas	Pellejas	206
13R-2	Adjuntas	Juan Gonzalez	213
13R-3	Adjuntas	Yayales	201
13R-4	Adjuntas	Guilarte	224
			232
23R-2	Lares	Bartolo	201
			202
			203
			236
			257
23R-4	Lares	Lares	220
			221
			222
			223
			224
23R-3	Lares	Callajones	210
			212
			213
			214
			215

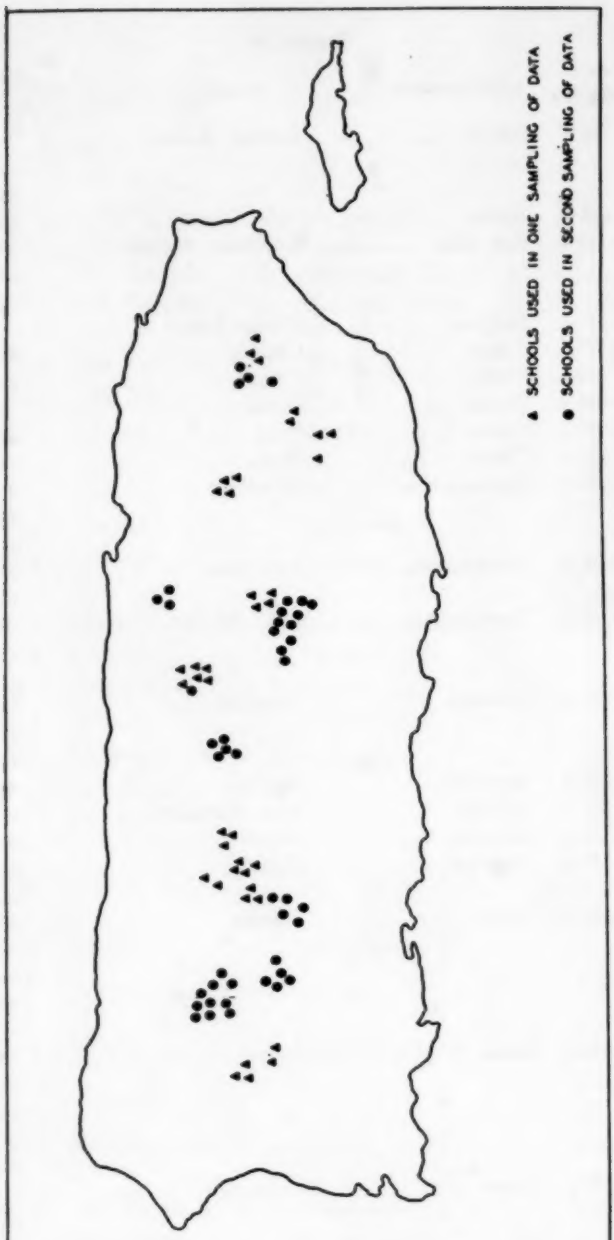


FIG. 1. MAP OF PORTO RICO SHOWING LOCATION OF SCHOOLS USED FOR TWO INDEPENDENT SAMPLINGS OF RURAL CHILDREN

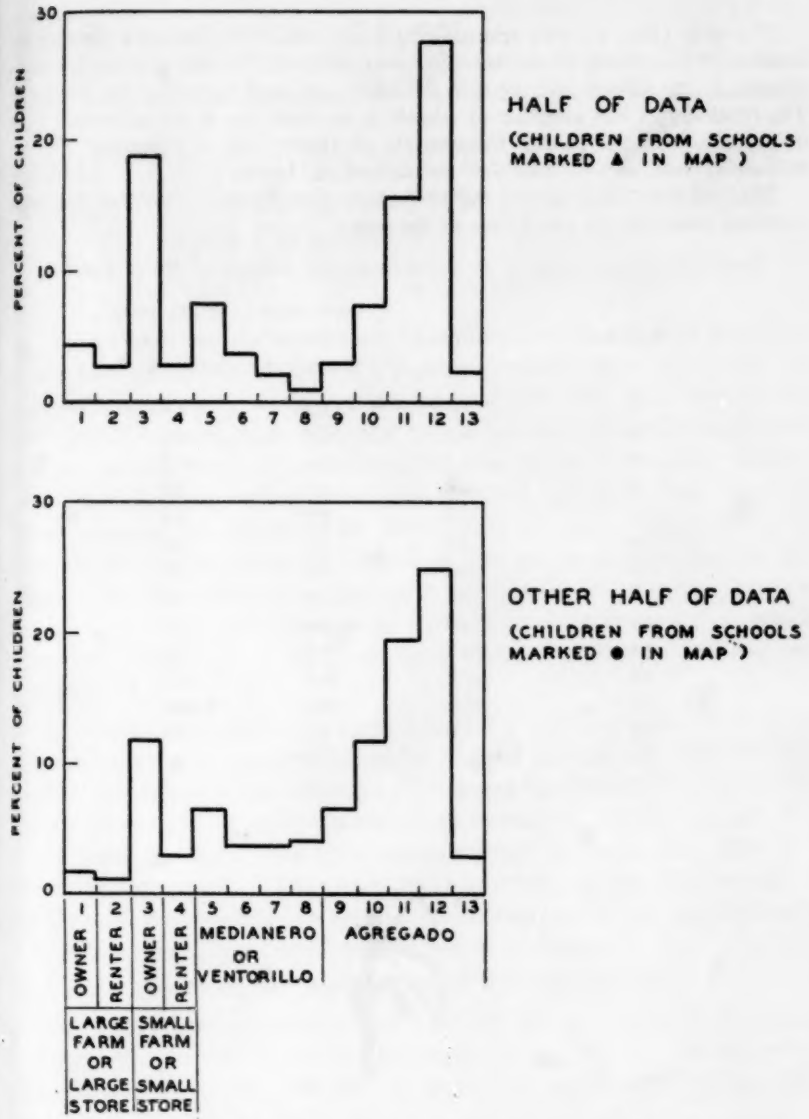


FIG. 2. PERCENTAGE DISTRIBUTION OF RURAL CHILDREN BY SOCIO-ECONOMIC RATING OF FAMILY FOR TWO HALVES OF THE DATA

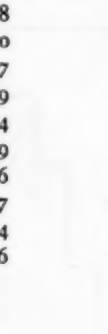
These percentages are presented in two graphs in Figure 2 to show the similarity in socio-economic grouping in the two halves of the data. This similarity suggests the consistency of the socio-economic grouping and we may therefore expect that other samples of school children distributed as these were would result in similar socio-economic groupings. We may, therefore, regard the sample as representative of the areas studied.

The map (Fig. 1) with triangles (▲) and dots (●) indicates roughly the locations of the schools where these data were obtained. The triangles represent one division of the schools and the dots the other half used in testing the reliability. The reliability of this sampling of schools is no doubt due to the assistance given us by officials of the Insular Departments of Health and of Education who are thoroughly familiar with conditions throughout the Island.

The following table shows the percentage distribution of children by socio-economic classes in the two halves of the data:

Percentage Distribution of 13 Socio-Economic Ratings of Rural Families

RATING	TOTAL	ONE HALF OF DATA SAMPLE ▲	OTHER HALF OF DATA SAMPLE ●
1	2.8	4.3	1.5
2	1.9	2.7	1.1
3	15.3	19.0	11.8
4	2.8	2.8	2.8
5	7.0	7.7	6.4
6	3.7	3.7	3.6
7	2.9	2.1	3.6
8	2.4	.9	3.8
9	4.9	3.0	6.5
10	9.6	7.5	11.6
11	17.7	15.8	19.5
12	26.4	27.9	24.9
13	2.6	2.5	2.8



BIOMETRIC STUDIES ON U. S. ARMY OFFICERS—SOMATOLOGICAL NORMS, CORRELATIONS, AND CHANGES WITH AGE*

BY LOWELL J. REED AND ALBERT G. LOVE

For many years Army officers have had careful physical examinations when commissioned and at irregular intervals when promoted. In addition, since 1907, when the annual test ride was first ordered by President Roosevelt, each one has had a careful physical examination at least once a year. Quantitative data in regard to stature, weight, chest measurement, pulse rate, systolic blood pressure, and diastolic blood pressure are recorded on the reports of these examinations in addition to the notations in regard to the physical condition of the officer. We thus have an opportunity to observe these anthropometric measurements with any changes in them or in their interrelation which occur with time, and in addition their relation to health and life expectancy.

To obtain information in regard to these and other biometric questions, a study was undertaken some months ago of the physical and medical records of 5,000 officers. It was our intention to include in the sample all officers who were in the active service on January 1, 1901 and in addition the ones who were commissioned between that time and December 31, 1916. This group was, however, larger than we could handle with the available personnel, and consequently we included only those whose surnames began with letters A-P, inclusive.

Table 1 shows the age distribution of the ones included.

Since very few are commissioned before the age of 21, the grouping is 21-25, etc., instead of the conventional 20-24, etc. In the following study it was necessary, however, to group by ten years after the 25th year.

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TABLE 1

Number of Officers in Each 5-Year Age Group on January 1, 1901 or When Commissioned at a Later Date

	NUMBER IN EACH AGE GROUP		
AGES	On January 1, 1901	When commissioned between January 1, 1901 and December 31, 1916	Total
16-20	2	6	8
21-25	197	2088	2285
26-30	354	849	1203
31-35	260	203	463
36-40	196	104	300
41-45	206	32	238
46-50	172	16	188
51-55	108	7	115
56-60	139	10	149
61-64	71	1	72
Total	1,705	3,316	5,021

The maximum number of years that any officer was under observation by the use of the records, was 28.5, or from January 1, 1901 until about June 30, 1929; the average time while on the active list, 17.5; and the average time including that on the retired list, 20. Since, however, we included data from physical examinations recorded many years before 1901, the actual period of observation was much greater.

A paper which was based upon these data, "Biometric Studies on U. S. Army Officers; Longevity in Relation to Physical Fitness," was read before the Medical Section of the American Life Convention in Washington in May 1931. It was published in the "Proceedings of the Twenty-first Annual Meeting." The subject matter of this one, and of the third one upon the relation of these same measurements to disease expectancy, and more especially to the expectancy of cardiovascular-renal diseases, tuberculosis, and mental and nervous diseases, is from the same source.

STATURE

Stature or height has apparently been considered as an important measure in the comparison of races, in the recruiting of armies, etc., for a number of years. Since only a few officers have been commissioned who were below 64 inches in height, their averages by age groups are not comparable with those of the general population.

As has been noted by a number of observers, men do not attain their full growth until the age of 25 or even thereafter. Thus the difference between the mean at 21-25 and at 26-35, .22±.040 inches, though small, is apparently a significant one. After the age 26-35, there is a slight though probably not a real decrease in stature as measured in the inch.

If we observe the same individuals for a number of years, we find practically the same changes. Thus the average stature of 730 men, whom we were able to follow from 21-25 through the 46-55 decade, changed from 68.67±.052 at 21-25 to 69.29±.057 at 26-35, to 69.28±.054 at 36-45, and to 69.24±.053 at 46-55. Similarly in a group of 99 men under observation from the age 21-25 to 56-64, with the exception of the 26-35 decade, for which there were no data, it was: 21-25, 68.78±.12; 36-45, 69.51±.15; 46-55, 69.41±.14; 56-64, 69.44±.14. The difference between the mean at 21-25 and 36-45 (.73±.20), although small, is apparently a significant one.

TABLE 2

Variation of Stature (inches) Constants With Age

AGES	21-25	26-35	36-45	46-55	56-64
Mean	68.91 ±.030	69.13 ±.026	69.12 ±.026	69.05 ±.032	68.84 ±.055
Median	68.86 ±.038	69.13 ±.032	69.14 ±.032	69.10 ±.041	68.96 ±.069
Standard deviation	2.17 ±.021	2.16 ±.018	2.18 ±.018	2.19 ±.023	2.21 ±.039
Coefficient of variability	3.15 ±.031	3.12 ±.026	3.16 ±.026	3.17 ±.033	3.21 ±.057
Number	2,360	3,198	3,232	2,071	720

The skewness is apparently slight and there is but little difference between the mean and the median of the different age periods.

Since there is slight, if any, age variation in the stature after 25, there should be but little change in the dispersion. The standard deviation shows that this assumption is correct and that there is no significant change in it as the men grow older, the difference between the one at 21-25 and 56-64 being only .040±.044. There is also no real change in the coefficient of variability; the greatest increase, which is between the one at 26-35 and 56-64, is only .09±.062, certainly not a significant difference.

WEIGHT

Weight, and more especially weight in relation to height and age, is an important biometric measure. It was not until about 50 years ago that it was considered important in the selection of military recruits, or apparently in the selection of Life Insurance risks. It appears that attention was first called to this subject in 1836 by Quetelet(1). He published a table giving one average weight and one average height for the ages 20, 30, 40, 50, and 60. Subsequently such tables were gradually enlarged and additional details added. Hunter of the New York Life Insurance Company says that an American life insurance height and weight table was published in 1869, but apparently the first one which was based upon a considerable volume of statistics and which took age into account was that compiled in 1897 by Dr. George R. Shepard(2). It was not until 1887 that a standard table of weight in relation to height was published for the United States Army, and not until 1894 that such requirements were specified for West Point candidates.

Although as stated the average stature of Army officers differs from that of the general population, due to the exclusion of practically all applicants below 64 inches, a comparison of their weight data with

TABLE 3

Variations of Weight (pounds) Constants With Age and the Relation of Weight and Stature

AGES	21-25	26-35	36-45	46-55	56-64
Mean	146.66 ± .23	154.49 ± .24	160.19 ± .26	164.02 ± .33	164.91 ± .58
Median	144.85 ± .29	152.15 ± .30	158.40 ± .33	163.13 ± .42	163.46 ± .72
At stature of 70 inches	151.27	158.21	164.10	168.19	169.81
Standard deviation	16.57 ± .16	20.18 ± .17	21.87 ± .18	22.55 ± .24	22.93 ± .41
Coefficient of variability	11.30 ± .11	13.07 ± .11	13.65 ± .12	13.75 ± .15	13.90 ± .25
Correlation with stature	.5536 ±.0096	.4558 ±.0094	.4429 ±.0095	.4280 ±.0121	.4059 ±.0212
Number	2,360	3,198	3,232	2,071	720

those published in the Medico-Actuarial Report of 1912(1) shows that, although an exact one cannot be made because Army officers are measured without clothing whereas life insurance applicants are measured with at least a part of theirs on, the average of the Army group for height and age is practically the same as that of the insured group.

There is a material increase in the average weight as age advances. The greatest increase, however, takes place during the earlier years and there is little, if any, after the age 55. Thus the difference between the mean of the 21-25 group and that of the 26-35 one is 7.83 lbs. This declines to 5.70 lbs. during the next 10 years, then to 3.83, and finally to .89 between 46-55 and 56-64, which is not a significant difference since its probable error is $\pm$ .67.

The average weight of the 730 men, for whom we had a consecutive history from 21-25 to 46-55, is 144.19$\pm$.39 lbs. at 21-25; 157.13$\pm$.59 at 26-35; 162.17$\pm$.61 at 36-45; and 163.71$\pm$.52 at 46-55. Similarly, in the group of 99 men whom we were able to follow from the age of 21-25 to 56-64, with the exception of the 26-35, it increased from 141.19$\pm$1.07 lbs. at the age 21-25 to 162.97$\pm$1.65 at 36-45; to 166.08$\pm$ 1.49 at 46-55; and to 166.65$\pm$1.51 at 56-64. The changes then in the age-mean-weights of these two groups are quite similar to those of the general group. They again show that although a material increase occurs during the earlier ages, there is no significant change after 55.

To find if the constitutional causes of the variation in weight remain constant as age advances, we selected two sets of three groups each composed of: (a) Those whose weight was 15 lbs. less than an ideal average (that at age 30); (b) those whose weight was more than 20 lbs. above the ideal average; and (c) those whose weight was between the (a) and (b) classes. For the first set we took the data at 21-25 and then found the average weight for each group at 46-55.

CLASSIFIED AT 21-25	NO. OF MEN	AVERAGE WEIGHT AT	
		21-25	46-55
Light group	119	128.80 lbs.	153.25 lbs.
Medium group	581	144.88 lbs.	163.15 lbs.
Heavy group	27	181.11 lbs.	195.63 lbs.

We then took for the second set the data at 46-55 and found what the average weight had been at 21-25.

CLASSIFIED AT 46-55	NO. OF MEN	AVERAGE WEIGHT AT	
		46-55	21-25
Light group	57	132.49 lbs.	132.16 lbs.
Medium group	457	155.43 lbs.	141.12 lbs.
Heavy group	211	186.27 lbs.	151.86 lbs.

There is a considerable increase in the average weight of the first set of three groups between 21-25 and 46-55. Although the greatest actual increase is in the light one, the average for it remains less than the one for the medium group, and much less than that for the heavy group. We also see from the second set that those who are light later in life have always been light.

The median for the general group, which is approximately the same distance to the left of the mean, at each age group, shows that the distributions are skewed, but apparently not enough to interfere with the use of the linear correlation method. The median remains in the same relative position to the mean because the increase in the latter is caused by a general one and not by one limited to a few men. There is approximately the same increase in medians as in the means, with the greatest one early and but little, if any, late in life.

Not only is there an increase in the average and median weight as the men grow older, but there is a corresponding one in the standard deviation, or the amount of spread. The difference between the one at 21-25 and at 56-64 is $6.36 \pm .44$ lbs., which is certainly a significant change. The greatest change again occurs during the earlier years. The coefficient of variability also becomes greater with age, the difference between the one at 21-25 and 56-64 being $2.60 \pm .27$.

The correlation coefficient of height and weight at age 21-25 is .5536, a fairly high one. As men grow older, some of them increase in weight, the dispersion of the weight becomes larger, stature remains unchanged, and hence the correlation decreases. Consequently there is a slight progressive decline in the correlation coefficient to .4059 at 56-64. Since there is but little change in the stature after the age of 25, the holding of height constant does not materially affect the age changes of weight, the total increase between 21-25 and 56-64 being 18.54 lbs. as compared with the unrestricted 18.25.

When the chest measurement, pulse rate, systolic blood pressure, and diastolic blood pressure are held constant by the partial correlation method, the correlation coefficient between height and weight is but slightly changed. For the various age groups it is .4913, .4317, .4394,

.4698, and .4016. There is then a definite and constant relationship between height and weight which is not influenced by the other variables which we are considering in this paper.

CHEST

Although, as stated, the weight in relation to height was formerly not a regulated quantity in the selection of recruits, the circumference of the chest was thought to be indispensable as an accompaniment to a certain degree of stature; and in the English recruiting regulations, instructions were carefully laid down in regard to it(3).

The chest measurements referred to in this paper are those at expiration.

The average increases materially with age. The difference between the one at 21-25 and at 56-64 is 2.67±.069. As with weight, most of the increase is during the early years, with but little at the advanced ages. The median is again slightly to the left of the mean, and again maintains about the same relative position to it. Thus at 21-25 it is

TABLE 4

Variation of Chest Measurement (exp. inches) Constants With Age, and the Relation of Chest With Stature and Weight

AGE	21-25	26-35	36-45	46-55	56-64
Mean	33.25 ± .024	34.23 ± .024	34.99 ± .027	35.61 ± .036	35.92 ± .064
Median	33.13 ± .030	34.00 ± .030	34.81 ± .034	35.53 ± .045	35.73 ± .080
At stature of 70 inches	33.54	34.46	35.25	35.88	36.30
At weight of 160 pounds	34.30	34.71	34.97	35.21	35.46
Standard deviation	1.74 ± .017	2.04 ± .017	2.28 ± .019	2.43 ± .026	2.55 ± .045
Coefficient of variability	5.24 ± .052	5.96 ± .050	6.52 ± .055	6.83 ± .072	7.09 ± .127
Correlation with:					
Stature	.3309 ±.0124	.2837 ±.0110	.2754 ±.0110	.2527 ±.0139	.2872 ±.0231
Weight	.7507 ±.0061	.8531 ±.0032	.8753 ±.0028	.8958 ±.0029	.8833 ±.0055
Number	2,338	3,197	3,230	2,066	716

.12 inches to the left and at 56-64, .19, showing that the increase is, broadly speaking, a general one.

Although the magnitude of the chest measurement is less than one-half as great as that of the stature, the standard deviation is almost as great and at some ages even greater. Consequently the coefficient of variability in the various age groups is approximately twice as great as that of stature. The standard deviation like that of weight grows greater with age, the increase between the one at 21-25 and at 56-64 being $.81 \pm .048$ inches. Here again the greatest increase is during the earlier years, with diminishing ones thereafter.

The correlation coefficient between weight and chest measurement, which is .7507 at 21-25, increases to a maximum of .8958 at 46-55. It then declines slightly to .8833 at 56-64. This high correlation coefficient is not reduced when the other four variables considered here are held constant either singly, or combined in any way. With a weight of 160 pounds, the chest measurement increases 1.16 inches in 35 years as compared with 2.67 with weight unrestricted. Thus more than one-half of the increase in the chest measurement during the 35 years, or 1.51 inches, is associated with the increase in weight.

There is only a low correlation between chest and stature. The maximum one is at 21-25, .3309; and the minimum one at 46-55, .2527. When weight is held constant, the height-chest correlation coefficients become negative, and are —.1540, —.2263, —.2590, —.3254, and —.1423 by age groups from 21-25 to 56-64. When the military authorities formerly insisted upon a well-formed chest in relation to height, they were unwittingly insisting upon a proper relation of weight to height. The holding of the stature constant at 70 inches affects but slightly the age changes in the average chest, the increase in it from 21-25 to 56-64 being 2.76 as compared with 2.67 when stature is unrestricted.

PULSE

The average pulse rate is higher than we expected to find it. How much of the apparent excess was due to excitement and how much to posture is difficult to say. Addis, Schneider, and others have noted the very material difference in the pulse rate with change in posture. Thus Schneider and Truesdell, working in the Medical Research Laboratory and School for Flight Surgeons at Mitchel Field, Long Island, New York, found that the pulse rate in an unselected group of aviators when taken reclining was 74 and 75 and that on standing it rose to 90 and 92. They also found in a selected group of physically fit men a reclin-

ing pulse of 72 and 70, which rose on standing to 83 and 86(4). In this group the rate was 80.90 at 21-25, which increased to 83.02 at 26-35. After that time, there was a slight decline through the different age groups to 82.32 at 56-64, but the difference .70±.21 is small.

The average pulse of 8,000 officers when examined in 1928 was, by the same age groups, 78.05, 77.48, 79.03, 79.49, and 80.23. Probably the differences between these averages and the ones for the group which we are considering were due at least in part to the posture when examined. Prior to the World War, there were no definite instructions in regard to it and, no doubt, some of the observations were made with the officers standing. During recent years, however, the directions have specified that it should be taken with the officers sitting.

TABLE 5

Variation of Pulse (beats) Constants With Age, and the Relation of Pulse to Stature, Weight, and Chest

AGE	21-25	26-35	36-45	46-55	56-64
Mean (with stature)	80.90 ± .13	83.02 ± .09	82.95 ± .09	82.74 ± .12	82.32 ± .19
Median	79.55 ± .16	82.37 ± .11	82.28 ± .11	82.02 ± .14	81.69 ± .24
At stature of 70 inches.....	81.02	83.12	82.97	82.56	82.03
At weight of 160 pounds	80.91	83.04	82.95	82.72	82.25
At systolic b. p. of 130.....	82.23	82.97	82.52	82.27	81.31
Standard deviation	8.26 ± .09	7.17 ± .06	7.38 ± .06	7.79 ± .08	7.64 ± .14
Coefficient of variability	10.21 ± .12	8.64 ± .08	8.90 ± .08	9.42 ± .10	9.28 ± .08
Correlation with:					
Stature	.0328 ±.0158	.0372 ±.0122	.0055 ±.0119	—.0561 ±.0148	—.0790 ±.0250
Weight	.0153 ±.0158	.0245 ±.0123	.0441 ±.0119	.0266 ±.0148	.0401 ±.0251
Chest	.0015 ±.0158	.0311 ±.0122	.0479 ±.0119	.0423 ±.0148	.1258 ±.0248
Number	1,820	3,025	3,220	2,070	719

The median is slightly to the left of the mean. It maintains about the same relative position, the difference at 21-25 being 1.35 and at 56-64, .63. Although the magnitude of the pulse rate as recorded in beats is only 20 per cent greater than that of stature in inches, the variability of the pulse rate as measured by the standard deviation is almost 3.5 times as great, and as measured by the coefficient of variability, 3 times. As with stature, since there is no significant change in the average pulse rate as the men grow older, there is no change in its variability.

There is little, if any, significant correlation in any age group between pulse and stature. Such slight correlation as exists, if it is at all significant, is negative. There is also no significant zero order correlation between weight and pulse, but when stature is held constant there is a very small positive significant one. There is again a very low zero order correlation if any, between the chest and the pulse, but such as there is is increased by the elimination of stature. Holding stature at 70 inches, or the weight at 160 pounds, affects but slightly, if at all, the age changes in the pulse rate.

SYSTOLIC BLOOD PRESSURE

Blood pressures have been recorded on the reports of the physical examinations since 1916. The mean increases from 122.04 at 21-25 to 139.77 at 56-64, a difference of 17.73 in 37 years. Although the greatest increase in the weight mean occurs during the thirties and forties, in systolic it is during the fifties and sixties. Thus the increase during the first 7.5 years is 1.74 mm., in the next ten 2.13, then 4.99, and finally 8.87. When the readings for all officers who developed a cardiovascular-renal disease are excluded the means are: 122.04, 123.61, 125.29, 129.15, and 136.58.

The median is again slightly to the left of the mean, but whereas the difference remains constant for weight and chest measurements, it increases here with age. Thus while it is only .52 mm. to the left at 21-25, it gradually increases to 3.30 at 56-64. Apparently the more rapid increase of this mean as compared with the median is due to the high readings of a comparatively small number of individuals. The blood pressure of the general group does not increase to the same extent as the weight.

The standard deviations are much smaller than those of weight, but like those of weight and chest become greater as age advances, increas-

ing by 10.50 in 37 years. As with the mean, however, but little change occurs until late in the forties or in the early fifties, and more than 50 per cent of the total increase is during the last ten years. The coefficient of variability also becomes larger with age, the greater part of the change occurring in the last two decades. It is much less than that of weight until age 55, but slightly greater thereafter.

TABLE 6

Variation of Systolic Blood Pressure Constants With Age, and the Relation of it to Stature, Weight, Chest and Pulse

AGE	21-25	26-35	36-45	46-55	56-64
Mean	122.04 ± .38	123.78 ± .16	125.91 ± .15	130.90 ± .23	139.77 ± .57
Median	121.52 ± .47	122.85 ± .20	124.36 ± .19	128.98 ± .29	136.47 ± .71
At stature of 70 inches	122.28	124.13	126.03	130.80	139.37
At weight of 160 pounds	123.28	124.43	125.96	130.47	139.15
Standard deviation	9.20 ± .27	9.28 ± .11	11.00 ± .11	14.32 ± .16	19.70 ± .40
Coefficient of variability	7.54 ± .22	7.50 ± .09	8.74 ± .08	10.94 ± .13	14.10 ± .29
Correlation with:					
Stature	.0673 ±.0408	.0969 ±.0168	.0260 ±.0136	—.0185 ±.0161	—.0414 ±.0289
Weight	.1966 ±.0394	.2427 ±.0160	.2507 ±.0127	.1725 ±.0157	.1470 ±.0283
Chest	.0421 ±.0401	.2589 ±.0159	.2497 ±.0127	.2053 ±.0155	.1857 ±.0281
Pulse	—.0253 ±.0409	.1489 ±.0166	.2814 ±.0125	.2044 ±.0155	.2497 ±.0271
Number	271	1,576	2,463	1,747	543

If there is any significant correlation between height and systolic blood pressure, it is very low, and even such as exists is negative, and especially so when weight is held constant. The correlation coefficient between weight and systolic blood pressure increases from .1966 at 21-25 to .2507 at 36-45 and then declines to .1470 at 56-64. It is in-

creased by holding height constant. Chest measurement is so intimately related to weight that the elimination of it reduces this correlation coefficient and even makes the one for each of the last two decades negative. There is also such a close relationship between systolic and diastolic blood pressure, that holding the diastolic one constant again reduces this coefficient. Apparently, however, there is a definite though rather low positive correlation betweer. weight and systolic blood pressure.

Practically the same remarks apply to the correlation between chest and systolic. This coefficient is even slightly greater than the one between weight and systolic. It is again increased by the elimination of height, much reduced by the elimination of weight, to which chest is so closely related, and also much reduced by the elimination of diastolic blood pressure with which the systolic is so closely correlated. Probably then there is a low zero order positive correlation between chest and systolic blood pressure.

There is a significant though low positive correlation between systolic blood pressure and pulse rate during the last four decades. The increase is rather uniform from —.0253 at 21-25 to .2497 at 56-64. The elimination of height, weight, or chest measurements either singly, in pairs, or all combined, fails to reduce them or to change their signs; but the elimination of the diastolic blood pressure does affect them very materially. Probably, however, this is more an indication of the close relationship between the systolic and diastolic blood pressure than of the absence of correlation between pulse and systolic.

With a stature of 70 inches, the increase in the systolic pressure between 21-25 and 56-64 is 17.09 as compared with 17.73 when stature is unrestricted. Similarly with a weight of 160 pounds, the increase in 37 years is 15.87, or only a slight reduction of the unrestricted change. In both instances more than one-half of the total change occurs during the last ten years, just as when the mean was considered without regard to any variable other than time.

DIASTOLIC BLOOD PRESSURE

Clinicians are devoting an increasing amount of attention to the subject of diastolic blood pressure. It is apparently less influenced by excitement and other extraneous factors than the systolic. The mean at 21-25 is 81.50 and at 26-35, 80.42. The difference $1.08 \pm .41$ is, however, less than three times as great as its probable error. The in-

creases during the decades that follow are: .52, 2.23, and 2.74. As with the systolic, practically all of the increase occurs during the last two decades. The percentage of the total increase in 37 years is 5.4 per cent as compared with 14.5 per cent in the systolic.

The median again is slightly to the left of the mean. At 21-25 it is 1.12 mm.; and .60, .79, 1.12, and 1.29 during the following age periods.

TABLE 7

Variation of Diastolic Blood Pressure Constants With Age, and the Relation of it to the Other Variables

AGE	21-25	26-35	36-45	46-55	56-64
Mean	81.50 ± .38	80.42 ± .14	80.94 ± .12	83.17 ± .16	85.91 ± .34
Median	80.38 ± .48	79.82 ± .18	80.15 ± .15	82.05 ± .20	84.62 ± .43
Mean:					
At stature of 70 inches	81.44	80.42	81.07	82.98	85.82
At weight of 160 pounds	82.08	80.80	80.98	82.84	85.44
At systolic of 130	83.67	83.13	82.99	82.82	81.95
Standard deviation	9.44 ± .27	8.30 ± .10	8.55 ± .08	9.57 ± .11	11.63 ± .24
Coefficient of variability	11.59 ± .34	10.32 ± .13	10.56 ± .10	11.51 ± .14	13.53 ± .14
Correlation with:					
Stature	.0243 ±.0406	—.0015 ±.0174	.0387 ±.0138	—.0130 ±.0165	—.0166 ±.0295
Weight	.0829 ±.0403	.1566 ±.0169	.2288 ±.0131	.1997 ±.0158	.1912 ±.0284
Chest	.0436 ±.0405	.1504 ±.0170	.2264 ±.0132	.2150 ±.0157	.2338 ±.0279
Pulse	.1012 ±.0402	.1560 ±.0169	.2610 ±.0129	.2759 ±.0152	.2447 ±.0278
Systolic	.2590 ±.0394	.4828 ±.0134	.6141 ±.0087	.7264 ±.0078	.7366 ±.0136
Number	276	1,508	2,366	1,677	522

The percentage of the shift in the last four age groups is about the same as that of the systolic, indicating that the changes in the two are closely related. The coefficient of variability is greater than that of the systolic blood pressure during the first three age groups, but about the same in the last two. As with the systolic pressure most of the increase in the variability occurs during the last two decades.

Diastolic blood pressure, like systolic, is but slightly, if at all correlated with height, and such correlation as exists is largely negative in character. The negative coefficient is increased when either weight or chest measurement is held constant, indicating possibly that tall men are apt to have lower blood pressure than the short ones. There is a significant though low zero order positive correlation between weight and diastolic blood pressure, which is slightly increased by eliminating height, but is not affected by holding pulse constant. It is reduced, however, by holding chest and systolic blood pressure constant, the former possibly on account of its intimate relationship with weight and the latter because of its high correlation with the diastolic.

Practically the same remarks apply to chest and diastolic blood pressure. There is here again a low zero order positive correlation which is increased by the elimination of height, unaffected by pulse, and somewhat reduced by holding the weight or systolic blood pressure constant, due apparently to the close relationship on the one hand between weight and chest, and on the other hand between diastolic and systolic blood pressure.

There is also a small positive correlation between pulse and diastolic blood pressure. This coefficient is unaffected by the elimination of height, weight, and chest, either singly, in pairs, or all combined. It is, however, materially reduced by holding systolic blood pressure constant, due apparently to the high correlation coefficient between diastolic and systolic blood pressure.

As stated, there is a high zero order positive correlation between systolic and diastolic. It increases from a minimum of .2590 at 21-25 to the maximum of .7366 at 56-64. This correlation coefficient is but slightly, if at all, affected by the elimination of all the other variables, either singly or in groups of twos, threes, or fours.

With a stature of 70 inches, the difference between systolic blood pressure at 21-25 and 56-64 is 4.38, as compared with the unrestricted increase of 4.41. With a weight of 160 pounds, the change in the 37 years amounts to 3.36. When, however, systolic blood pressure is held

at 130 mm., there is a constant and rather uniform reduction as age advances, the maximum being 83.67 at 21-25 and the minimum 81.95 at 56-64, a total reduction of 1.72 in 37 years.

CONCLUSIONS

1. After 25 years of age, there is no significant change in the mean or median of either the stature or the pulse rate. The variability of each one also remains unchanged.

2. There is a significant but progressively declining increase in the mean and median of both weight and chest measurement. This increase, which is generally distributed, occurs almost entirely during the late twenties, thirties, or forties, and there is but little, if any, change after fifty-five. This increase we may call physiological, because it antedates any disease which may be associated with it later.

3. Coincident with the increase in the mean and median, and as an indication of the greater dispersion, there is also an increase in the variability as measured both by the standard deviation and the coefficient of variability.

4. There is also a significant increase in the mean and median of both systolic and diastolic blood pressure. The change is, however, not material until late in life and becomes apparent chiefly in the fifties and sixties. Since this increase occurs principally during the ages when degenerative changes are occurring in the cardiovascular-renal system, we may term it a pathological one as distinguished from the physiological changes in weight and chest. The mean moves farther to the right than the median as age advances, indicating that the increase in it is due to that of individuals rather than of the general group of men.

5. Coincident again with the increase in the mean and in the median there is an increase in the variability which also occurs late in life, and especially during the late fifties and the sixties.

6. The only other variable with which stature has a significant correlation coefficient is weight, and this one decreases as the men grow older and the dispersion of the weight increases. The stature-chest correlation, which is a low zero order positive one, becomes negative when weight is eliminated. Judged largely by the effect of its elimination on the relation of either weight or chest to the pulse rate, systolic blood pressure, or diastolic blood pressure, there is apparently a small negative correlation between stature and pulse rate, stature and systolic blood pressure, and stature and diastolic blood pressure.

7. Weight is quite closely correlated with chest, the coefficient at 46-55 being .8958. There is a low zero order positive correlation of either weight or chest with both systolic and diastolic blood pressure, and a still lower one with the pulse rate. All of these are increased by the elimination of stature.

8. There is a low zero order correlation coefficient between the pulse rate and either systolic or diastolic blood pressure, which is negative at 21-25 but positive thereafter. It is not affected by the elimination of stature, weight, or chest measurement either singly or in combinations of two or more.

9. At 21-25, the zero order correlation coefficient between systolic and diastolic blood pressure is .2590. This increases as men grow older until the maximum of .7366 is recorded at 56-64. It is not affected by the elimination of any one or all of the other variables considered.

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SOME DATA ON FERTILITY AND ECONOMIC STATUS[1]

BY RAYMOND PEARL

THE PROBLEM

One of the major concerns of students of population problems has long been the question of the changes, actual or potential, in the quality of human populations, following as a statistical consequence upon the relative reproductive rates of socially and economically differentiated classes. The general question of the relative fertility of differentiated groups of organisms (local races, varieties, species, etc.) is one of the most fundamental in evolutionary biology. Darwin clearly understood that rates of reproduction of organisms were basic elements in his theory of natural selection. The sections on "Geometrical Ratio of Increase" and "Nature of Checks to Increase" in the third chapter of the *Origin of Species* are devoted to a discussion of reproductive rates. Later Darwin came to perceive still more clearly the potential significance of *innate* differences in fertility apart from the effects of external circumstances upon rates of reproductivity. In a letter[2] to A. R. Wallace, dated April 6, 1868, he said (Vol. I, p. 295): ". . . I look at the number of offspring as an important element (all circumstances remaining the same) in keeping up the average number of individuals within any area. I do not believe that the amount of food by any means is the sole determining cause of number. Lessened fertility is equivalent to a new source of destruction." Four years earlier Darwin (*loc. cit.*, Vol. II, pp. 328-9) was corresponding with Hooker relative to the employment of J. Scott "to investigate certain difficult and tedious points—viz. relative fertility of varieties of plants."

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[1] From the Department of Biology of the School of Hygiene and Public Health of the Johns Hopkins University. I am indebted to my colleague Dr. John R. Miner, for assistance in the preparation of this paper.

[2] More Letters of Charles Darwin. Edited by Francis Darwin, . . . and A. C. Seward. *London* (John Murray) 1903.

In 1869 Galton[3] set forth, with characteristic clarity and forthrightness, the influence of different fertility rates among different classes upon the future composition of human populations. He says (*loc. cit.*, pp. 356-8):

I trust the reader will realize the heavy doom which these figures pronounce against all sub-sections of prolific races in which it is the custom to put off the period of marriage until middle age. It is a maxim of Malthus that the period of marriage ought to be delayed in order that the earth may not be overcrowded by a population for whom there is no place at the great table of nature. If this doctrine influenced all classes alike, I should have nothing to say about it here, one way or another, for it would hardly affect the discussions in this book; but, as it is put forward as a rule of conduct for the prudent part of mankind to follow, whilst the imprudent are necessarily left free to disregard it, I have no hesitation in saying that it is a most pernicious rule of conduct in its bearing upon race. Its effect would be such as to cause the race of the prudent to fall, after a few centuries, into an almost incredible inferiority of numbers to that of the imprudent, and it is therefore calculated to bring utter ruin upon the breed of any country where the doctrine prevailed. I protest against the abler races being encouraged to withdraw in this way from the struggle for existence. It may seem monstrous that the weak should be crowded out by the strong, but it is still more monstrous that the races best fitted to play their part on the stage of life, should be crowded out by the incompetent, the ailing, and the desponding.

The time may hereafter arrive, in far distant years, when the population of the earth shall be kept as strictly within the bounds of number and suitability of race, as the sheep on a well-ordered moor or the plants in an orchard-house; in the meantime, let us do what we can to encourage the multiplication of the races best fitted to invent and conform to a high and generous civilization, and not, out of a mistaken instinct of giving support to the weak, prevent the incoming of strong and hearty individuals.

The long period of the dark ages under which Europe has lain is due, I believe in a very considerable degree, to the celibacy enjoined by religious orders on their votaries. Whenever a man or woman was possessed of a gentle nature that fitted him or her to deeds of charity, to meditation, to literature, or to art, the social condition of the time was such that they had no refuge elsewhere than in the bosom of the Church. But the Church chose to preach and exact celibacy. The consequence was that these gentle natures had no continuance, and thus, by a policy so singularly unwise and suicidal that I am hardly able to speak of it without impatience, the Church brutalized the breed of our forefathers. She acted precisely as if she had aimed at selecting the rudest portion of the community to be, alone, the parents of future generations. She practised the arts which breeders would use, who aimed at creating ferocious, currish and stupid natures. No wonder that club-law prevailed for centuries over Europe; the wonder rather is that enough good re-

[3] Galton, F. Hereditary Genius: an Inquiry into its Laws and Consequences. *London* (Macmillan) 1869. Pp. vi + 390.

mained in the veins of Europeans to enable their race to rise to its present, very moderate level of natural morality.

A relic of this monastic spirit clings to our Universities, who say to every man who shows intellectual powers of the kind they delight to honour, "Here is an income of from one to two hundred pounds a year, with free lodging and various advantages in the way of board and society; we give it to you on account of your ability; take it and enjoy it all your life if you like; we exact no condition to your continuing to hold it but one, namely, that you shall not marry."

Pearson,[4] at an early stage in the development of his biometric work attacked the problem of fertility in man, and came to certain conclusions which have not been essentially altered by subsequent work. He pointed out (*loc. cit.*, Vol. I, p. 67) that the variation constants for fertility vary markedly from race to race, nation to nation, and class to class in the same race or nation, and that (p. 100) "society after all 'recruits itself from below.'"

The first detailed study of the relative fertility of different social classes was the well-known memoir by Heron[5] published in 1906, and now by way of being a classic. Using the correlational calculus he reached the following conclusions:

As far as the present investigation goes it demonstrates I think conclusively that for the London districts there is a very close relationship between undesirable social status and a high birth-rate. In districts where there is overcrowding, where there is a superabundance of the lowest type of labour, where it is needful to employ many young children in order to earn daily bread for the family, where infantile mortality is greatest, there the wives of reproductive ages have most children. Where there is more culture and education as shown by a higher proportion of professional men, where there is more leisure and comfort as shown by a higher percentage of domestic servants, where the traders who appeal to the improvident and thriftless are fewer in number, there the birth-rate is least. Again, where there is more general pauperism, where signs of bad environment like phthisis are prevalent, where pauper lunatics are most plentiful, there the birth-rate is highest. Cancer alone of the undesirable physical conditions dealt with so far seems more prevalent in the prosperous and cultured districts and to be associated with a lower birth-rate.

Nor is the higher birth-rate of the undesirable elements compensated by the higher death-rate. The net fertility of the lower status remains higher than that of the superior status.

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[4] Pearson, K. Reproductive selection. *In* The Chances of Death and other Studies in Evolution. Two vols. *London* (Arnold) 1897. Pp. xii + 388 and iv + 460.

[5] Heron, D. On the relation of fertility in man to social status, and on the changes in this relation that have taken place during the last fifty years. *Drapers' Company Research Mem.*, Studies in National Deterioration, I. *London* (Dulau), 1906.

The relationship between inferior status and high birth-rate has practically doubled during the last fifty years, and it is clear that in London at least the reduction in the size of families has begun at the wrong end of the social scale and is increasing in the wrong way. I have brought forward evidence enough to show that the birth-rate of the abler and more capable stocks is decreasing relatively to the mentally and physically feebler stocks.

These results have, in general, been confirmed by later workers.[6] Only in a few exceptional cases, notable in Edin's [7] studies on the population of Stockholm, has anything been brought to light to indicate any divergent trend in the observed results. The interpretation of the meaning and social or biological significance of the observations is another matter, in which there is not quite so great a degree of uniformity as in the observations themselves. But with that side of the matter we are not concerned, for the moment. It will be admitted that there is general agreement that observations from a wide variety of populations and communities are alike, with few exceptions, in indicating that as the social and economic status of groups of people rises, their reproductive rates appear to diminish. It is also a fact, capable of easy verification, that in the main the evidence which has led to this conclusion is of a broadly statistical character. By that is meant that the groups which have been compared have been only broadly and rather vaguely defined—in many cases not even quantitatively. Precise data relating to individuals, of a sort comparable to what one acquires in an experimental laboratory investigation, have usually not been available for the discussion of the problem of differential human fertility.

The problem to which the present paper contributes some new data is the more precise determination of the relation between fertility and other variables related to human reproduction (as measured by rates per unit of time of exposure to risk), on the one hand, and economic status (as measured by family income in dollars per week), on the other hand. What is the degree and sign of the correlation between these two variables, when the value of each variable is known rather exactly for each individual woman entering the correlation table?

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[6] *Cf.* Pearl, R. Differential fertility. *Quart. Rev. Biol.*, Vol. 2, pp. 102-118, 1929.

[7] Edin, K. A. The birth rate changes. Stockholm "upper classes" more fertile than the "lower." *Eugenics Rev.*, Vol. 20, pp. 258-266, 1929.

MATERIAL

The material for the inquiry comes from the records of the first four years of the operation of the Bureau for Contraceptive Advice in Baltimore.[8] During this period of four years during which the Bureau has been operating, from November 2, 1927 to September 30, 1931 inclusive, 816 different patients have been given contraceptive advice. The clinical histories, which are taken for each case by the physician-in-charge, Dr. Bessie L. Moses, a thoroughly trained and experienced obstetrician, and the attending nurse, have been recorded with extreme care, insight and accuracy, and contain a wealth of material for the study of various medical and biological problems.

For each of these 816 women there are recorded, among other things, the following items pertinent to the present investigation:

1. Age.
2. Color (white or negro).
3. Date of marriage.
4. Number of pregnancies experienced throughout life up to the time of record.
5. Result of each pregnancy (whether living birth, miscarriage, etc.)
6. Family income per week in dollars. (This information was not obtained in the case of 88 of the women. In all cases where it was obtained it pertains to the conditions prevailing at or about the time of the inquiry.)

Table 1 shows the distribution of the 816 women studied relative to (a) age, and (b) duration of marriage.

While the net number of women available for the present study is but 728, the paucity of numbers is to a considerable degree compensated for by the manifoldness of the information recorded for each individual and its considerable precision. We are dealing here with detailed scientific records, got by a trained physician studying her patients. They are very different things in the matter of reliability than general birth statistics, as officially registered. Plainly no final conclusions applicable generally to all mankind are going to be reached from this sample of material. But it will, at least, be useful to record what this

[8] Pearl, R. Statistical report on the fourth year's operation of the Bureau for Contraceptive Advice. *Fourth Rept. Bur. Contraceptive Advice, Baltimore,* 1932, pp. 3-15.

TABLE 1

Age and Duration of Marriage

AGE	NUMBER	DURATION OF MARRIAGE	NUMBER
Years		*Years*	
15-19	17	0- 4	121
20-24	131	5- 9	242
25-29	228	10-14	249
30-34	227	15-19	147
35-39	157	20-24	44
40-44	46	25-29	13
45-49	10	30-34	—
Total	816	Total	816

particular sample does show regarding the two variables fertility and economic status. Furthermore it will illustrate the applicability of elementary actuarial methods and reasoning to the treatment of the problem, which I venture to think give a sounder and more penetrating insight into the meaning of the data than some of the methods which are usually applied to the discussion of fertility problems.

RESULTS

In the report already alluded to[9] there were published three correlation tables relating variables having to do with the reproductive history of the patient to her economic status. The captions of these three tables were as follows:

Table 6 (p. 10). Number of pregnancies, by income and color of patients advised, November 2, 1927-September 30, 1931.

Table 7 (p. 12). Number of children born, by income and color of patients advised, November 2, 1927-September 30, 1931.

Table 8 (p. 13). Number of miscarriages by income and color of patients advised, November 2, 1927-September 30, 1931.

The data from the first two of these tables were shown graphically in the Report, in a diagram which is here reproduced as Fig. 1.

[9] Pearl. *Loc. cit.*, footnote 8.

In commenting upon the apparent downward trend of the regression lines for the white women, and upward trend for the negro women, the following statement was made (pp. 11-12):

It is necessary to be cautious in interpreting these trends of fertility with changing income classes. Most of the marriages furnishing data for Tables 6-8 are not completed. That is, they have not endured yet to the end of the wife's physiological ability to become pregnant. There is a good deal of variation in the duration of marriage among these women. What is needed is to set up Table 6 in another form, in which there will be shown across the top *not* number of pregnancies as in the present table, but instead *number of pregnancies per each 10 person-years exposure to risk of pregnancy.* This procedure will eliminate the variable effect of differing durations of marriage. It is hoped to deal with the matter in this way in the near future, in another place of publication.

This present paper is offered in liquidation of the hope expressed in the last sentence.

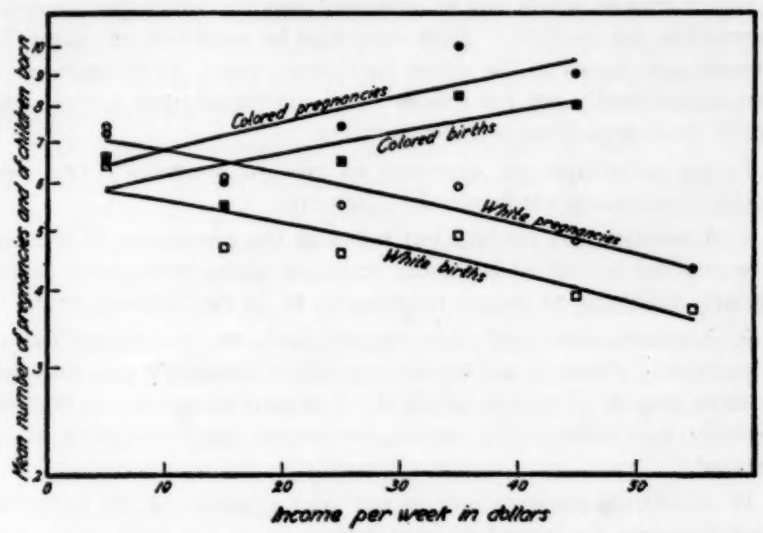

FIG. 1. SHOWING THE TREND OF TOTAL PREGNANCIES AND CHILDREN BORN AMONG COLORED AND WHITE PATIENTS

The data are plotted on an arithlog grid, in order to show comparative trends. The smooth lines have been fitted to the observations by the method of least squares, and the equations to the lines are as follows, y denoting pregnancies, and x dollars per week income, and with origin at 0 dollars:

Pregnancies, white:	$y = 7.30 - 0.054\,x$
Pregnancies, colored:	$y = 6.02 + 0.076\,x$
Children born, white:	$y = 6.04 - 0.045\,x$
Children born, colored:	$y = 5.58 + 0.056\,x$

Pregnancy Rates and Family Income

In dealing with fertility questions the usual procedure is to express the results in the form of mean numbers of children per marriage. This procedure is methodologically unsound, and likely to obscure the true relationships, unless all the marriages have (a) endured the same number of years, (b) been physiologically completed by virtue of each included wife having lived through the menopause, and (c) started at the same age and time. These conditions are practically never realized in any actual data.

The sound procedure, in contradistinction to the above, is to calculate for each observed marriage the exposure to risk of pregnancy of the female partner, and then from this datum compute the pregnancy rate per *n* person-years exposure, or the live birth rate, or any other particular rate in which one is interested and for which the necessary observations are available. Such rates may be separately calculated for different age classes of the wives (say 20-29 years, 30-39 years, etc.). They automatically put the results of all marriages upon a truly comparable basis regardless of their duration.

In the calculation of exposure to risk of pregnancy two basic biological postulates are involved. They are:

a. A woman past puberty but not past the menopause is assumed to be exposed to risk of becoming pregnant when she is more or less regularly indulging in sexual intercourse, as in the married state.

b. A woman who in all other respects conforms to the specifications of postulate *a* above, is *not* exposed to risk of becoming pregnant during those periods of time in which she *is* already pregnant. It is physiologically impossible for a women to *become* pregnant while she *is* pregnant.[10]

In calculating the exposure to risk of pregnancy of the individual married women the procedure is as follows:

From the total number of years (and fraction of a year[11]) between (from) the date of the woman's marriage and (to) the date of delivery from her last pregnancy there is *subtracted* the amount of time spent in

[10] This statement neglects, for practical reasons, the dubious "evidence" for the possibility of the excessively infrequent occurrence of human superfoetation.

[11] *Cf.* Pearl, R. and J. R. Miner. A table for ascertaining elapsed time in years and decimals of a year between any two dates. *Quart. Bull. Milbank Mem. Fund.*, Vol. 10, pp. 151-153, 1932.

pregnancy. In case the exact time is not known the following average deductions are made:

0.750 year for each living child she has borne and delivered at term;
0.750 year for each still-born child she has borne and delivered at term;
0.250 year for each spontaneous miscarriage she has had;
0.375 year for each therapeutic abortion she has had;
0.250 year for each other abortion she has had.

These subtractions are made because of the physiological fact that a woman is not at the risk of *becoming* pregnant during the time that she is *already* pregnant. The amounts subtracted represent estimated average figures for the various events other than the first two, *and are to be used only when more precise individual records are not available regarding the actual duration of the pregnancy ending before full term.* In the present data precise records of the duration of aborted pregnancies are known in some cases and not in others. The approximations have been used for the latter only.

Table 2 gives the correlation between income per week (in dollars) and pregnancy rate per 10 person-years exposure to risk of pregnancy. These rates as stated can be converted into rates per 100 person-years exposure by multiplying by 10, or to rates per single person-year exposure by dividing by 10, if anyone so desires.

The total number (656) of white women in Table 2 is 3 less than the total number of white women who have been advised at the Bureau during the first four years experience. The reason is that these three women came for advice and were examined just prior to their marriage, and consequently had presumably not been exposed to risk of becoming pregnant at the time the record was made.

From Table 2 the following points are to be noted:

1. Since true pregnancy rates, calculated upon a sound biological basis of exposure to risk, have only recently been presented or discussed,[13] so far as I am aware, their values will naturally be unfamiliar and seem strange. In particular some of the values will probably seem unduly large at first glance. But let us consider the matter carefully. Suppose a woman has been married exactly four years and has borne in

[13] Pearl, R. Contraception and fertility in 2000 women. HUMAN BIOLOGY, Vol. 4, pp. 363-407, 1932.

TABLE 2

Correlation Between Income per Week and Number of Pregnancies per 10 Person-years Exposure to Risk of Pregnancy in White Women, in the First Four Years Experience of the Bureau for Contraceptive Advice, Baltimore

INCOME PER WEEK (DOLLARS)	PREGNANCY RATE PER 10 PERSON-YEARS EXPOSURE												TOTALS	MEAN PREGNANCY RATES
	0-4.9	5.0-9.9	10.0-14.9	15.0-19.9	20.0-24.9	25.0-29.9	30.0-34.9	40.0-44.9	45.0-49.9	55.0-59.9	120.0-124.9	680.0-684.9		
0- 9.99	1	2	2	—	1	1	—	—	—	—	—	—	7	13.21
10- 19.99	16	42	30	8	9	1	—	6	1	1	1	—	115	13.76
20- 29.99	53	87	63	24	15	1	2	5	—	—	—	—	250	10.54
30- 39.99	34	49	24	7	3	—	1	1	—	—	—	—	119	8.55
40- 49.99	17	12	11	5	—	—	—	—	—	—	—	—	45	7.94
50- 59.99	9	7	6	1	2	—	—	—	—	—	—	—	25	8.50
60- 69.99	2	3	—	—	—	—	—	—	—	—	—	—	5	5.50
70- 79.99	2	—	1	1	—	—	—	—	—	—	—	—	4	8.75
80- 89.99	1	2	—	—	—	—	—	1	—	—	—	—	4	15.00
90- 99.99	1	2	—	—	—	—	—	—	—	—	—	—	3	5.83
100-109.99	1	—	—	—	—	—	—	—	—	—	—	—	1	2.50
110-119.99	1	—	—	—	—	—	—	—	—	—	—	—	1	2.50
130-139.99	—	1	—	—	—	—	—	—	—	—	—	—	1	7.50
190-199.99	1	—	—	—	—	—	—	—	—	—	—	—	1	2.50
Totals	139	207	137	46	30	3	3	13	1	1	1	—	581	10.37 ±.26
No information as to income	18	30	15	6	2	1	1	1	—	—	—	1	75	9.59[13]

[13] Omitting from the average the extreme observation (pregnancy rate 680). With this observation included the mean runs up to 18.56.

that time four babies at term. This is obviously an entirely possible history biologically. There is nothing physiologically abnormal about it. Indeed such a history occurs not very infrequently with highly fertile women, and its equivalent is usual among many of the mammals below man in the evolutionary scale. The true biological pregnancy rate of such a woman, per 10 person-years exposure to risk of pregnancy, is 40. This figure is reached in the following way. Out of her four years of wedded life she has spent three (i. e., 4×0.75 year) in the pregnant state, because for each of her four children she has been pregnant 9 months (0.75 year). But since she was not exposed to risk of becoming pregnant while she *was* pregnant there is left but one year in total out of her four years of wedlock in which she was exposed to risk of becoming pregnant. We then have for pregnancy rate per 10 person-years exposure to risk of becoming pregnant

$$\frac{4 \times 10}{(4-3)} = \frac{40}{1} = 40$$

But in Table 2 there are included four cases in which the pregnancy rates have values above the 40-44.9 class. It will be well to examine in detail the origin of these extremely high rates.

Case No. 72 had been married 5½ years and had had 2 living children and 15 self-induced abortions. Her exposure to risk of pregnancy was, therefore, $5.5 - (2 \times 0.75) - (15 \times 0.25) = 0.25$ person-year, and her pregnancy rate per 10 person-years exposed to risk $= \frac{17 \times 10}{0.25} = 680$. It is probable, in this case, that some or perhaps all of the self-induced abortions occurred at less than 3 months of pregnancy. But since there are no precise records on the point the average figure is used in the computation. This case is of significance only as an illustration of an extreme value which the pregnancy rate may take. It is not included in any of the subsequent calculations or discussion. Case No. 419 had been married 11 months or 0.92 year and had had 1 living child. Her exposure to risk of pregnancy was $0.92 - 0.75 = 0.17$ person-year, and her pregnancy rate per 10 person-years exposed to risk $= \frac{1 \times 10}{0.17} = 58.8$. Case No. 470 had been married 4 years, and had had 4 children, 3 of them recorded as born at 7 months, and 1 spontaneous abortion at 5 months. Her exposure to

risk of pregnancy was $4 - (3 \times 0.58) - (1 \times 0.75) - (1 \times 0.42) = 1.09$ person-year, and her pregnancy rate per 10 person-years exposed to risk $= \frac{5 \times 10}{1.09} = 45.9$. Case No. 760 had been married 10 months, or 0.833 year, and had had 1 child. Her exposure to risk of pregnancy was $0.833 - 0.75 = 0.083$ person-year, and her pregnancy rate per 10 person-years exposed to risk $= \frac{1 \times 10}{0.083} = 120$.

2. The biometric constants for the two distributions of Table 2 (excluding the bottom row of cases where information as to income was lacking) are as follows:

Pregnancy Rate

Mean ..... = 10.37 ± .26 pregnancies
Standard deviation ..... = 9.13 ± .18 pregnancies
Coefficient of variation..... = 88.1 ± 2.8 per cent

Family Income per Week

Mean ..... = $29.91 ± .45
Standard deviation ..... = $16.09 ± .32
Coefficient of variation..... = 53.8 ± 1.3 per cent

It is evident that these 581 women exhibited a high average pregnancy rate. I have already noted elsewhere [14] the extremely high fertility of this group of women. In an earlier paper [15] it has been shown that samples from the general population of white women consisting of 493 women practising contraception and 855 women not practising it exhibited mean pregnancy rates per 10 person-years exposure to risk of pregnancy of 6.43 and 7.80 respectively. It thus appears that the present group of women has experienced an average pregnancy rate which is about 63 and 33 per cent *higher* respectively than those exhibited by the two cited samples from the general population. It seems probable that women seeking a contraceptive clinic for advice will be found generally to be a more fertile group than the average of the general population of women.

These women exhibit a high degree of variation, as a group, in respect of their pregnancy rates. Indeed they are significantly more

[14] Pearl, R. *Loc. cit.*, footnote 8.
[15] Pearl, R. *Loc. cit.*, footnote 13.

variable in fertility than in family income, where a high degree of variability would naturally be expected.

3. The coefficient of correlation between pregnancy rate and weekly income from Table 2 is

$$r = -.168 \pm .027$$

This indicates a small, but statistically significant negative correlation; in the sense that in this material the women with the higher family incomes had the lower pregnancy rates, and *vice versa.*

4. While showing some irregularity because of the small number of entries in some of the arrays the regression appears to be linear within the limits of range of Table 2. The regression of pregnancy rate on family income is shown graphically in Fig. 2 *infra.*

The value of η for Table 2 is

$$\eta = .232.$$

$$\zeta = .0256 \pm .0089.$$

The regression is, therefore, probably linear.

The regression equations are

$$\text{Pregnancy rate} = 13.214 - .0952 \text{ (Weekly income)}.$$

$$\text{Weekly income} = 32.968 - .2955 \text{ (Pregnancy rate)}.$$

While the regression appears to be probably linear for this sample of material within the range limits of Table 2, it seems possible on theoretical grounds that with a larger body of material the approach of

TABLE 3

Correlation Between Income per Week and Number of Pregnancies per 10 Person-years Exposure to Risk of Pregnancy in Negro Women, in the First Four Years Experience of the Bureau for Contraceptive Advice, Baltimore

INCOME PER WEEK (DOLLARS)	PREGNANCY RATE PER 10 PERSON-YEARS EXPOSURE								TOTALS	MEAN PREGNANCY RATES
	0-4.9	5.0-9.9	10.0-14.9	15.0-19.9	20.0-24.9	25.0-29.9	30.0-34.9	40.0-44.9		
0- 9.99	1	1	2	1	—	—	—	—	5	10.50
10-19.99	2	17	25	13	8	1	2	6	74	16.22
20-29.99	2	17	11	9	11	3	—	1	54	14.81
30-39.99	1	2	1	2	1	—	—	—	7	12.50
40-49.99	—	3	—	1	—	—	—	—	4	10.00
50-59.99	1	—	—	—	—	—	—	—	1	2.50
Totals	7	40	39	26	20	4	2	7	145	15.00 ± .49
No information as to income	—	4	3	4	—	—	—	1	12	15.00

the pregnancy rate to zero with increasing income would be asymptotic rather than linear. Possibly the true regression curve is a compound one—linear within incomes up to say $100 per week, and some asymptotic curve after that point. Larger collections of material should throw light on the matter.

Table 3 presents data for the same variables as Table 2, but for negro women.

The following comments are pertinent to Table 3:

1. The biometric constants for the two variables of Table 3 are as follows:

Pregnancy Rate

Mean .....= 15.00 ± .49 pregnancies
Standard deviation .....= 8.75 ± .35 pregnancies
Coefficient of variation.....= 58.3 ± 3.0 per cent

Family Income per Week

Mean .....= $20.45 ± .43
Standard deviation .....= $7.61 ± .30
Coefficient of variation.....= 37.2 ± 1.7 per cent

The mean pregnancy rate is 4.63 ± .56 points, or about 45 per cent, higher in the negro women than it is in the white group attending the Bureau. This result accords with normal expectation from general knowledge of the reproductive habits of the negroes. Also the negro women are significantly less variable as a group than the whites in respect of pregnancy rates. The difference between the respective coefficients of variation is 29.8 ± 4.1. As would be expected the mean weekly income is significantly smaller in the negro than in the white group, the difference being $9.46 ± .62 per week.

The mean pregnancy rate for this group of negro women is 5.53 per 10 person-years exposure, or about 58 per cent, *higher* than a sample of 88 negro women practising contraception in the general population,[16] having a pregnancy rate per 10 person-years exposure of 9.47. A sample of 388 negro women not practising contraception, drawn from the general population gave (*loc. cit.*) a pregnancy rate of 8.30 per 10 person-years exposure. The mean pregnancy rate for the present sample of negro women is 6.70 or about 81 per cent *higher* than this. It is thus apparent that these negro women coming to the Bureau for

[16] Pearl, R. *Loc. cit.*, footnote 13.

Contraceptive Advice, like the corresponding group of white women, exhibit a fertility well above that of the general population.

2. The coefficient of correlation between pregnancy rate and weekly income calculated from Table 3 is

$$r = -.142 \pm .055.$$

This is insignificantly lower than the corresponding coefficient for the white group, and cannot be regarded as more than probably significant statistically, having regard to its probable error. But it is interesting to note that the upward slope of the regression line of fertility on weekly income depicted in Fig. 1 has been changed to a slight downward slope in these negro women, when an adequate measure of fertility replaces the crude mean number of pregnancies.

3. The regression line of pregnancy rate on weekly income from Table 3 is shown in Fig. 2.

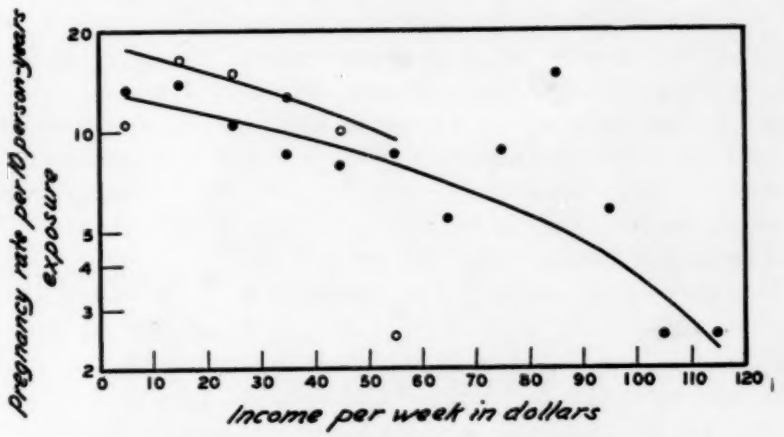

FIG. 2. REGRESSION OF PREGNANCY RATE PER 10 PERSON-YEARS EXPOSURE TO RISK OF PREGNANCY ON WEEKLY INCOME FOR (A) WHITE WOMEN AND (B) NEGRO WOMEN

Data from Tables 2 and 3. The solid circles are the observed points for whites, and the open circles for negroes.

The value of η for Table 3 is

$$\eta = .215$$

$$\zeta = .0261 \pm .0178.$$

The regression is, therefore, linear.

The regression equations computed from Table 3 are:

Pregnancy rate = 18.330 — .1628 (Weekly income).

Weekly income = 22.293 — .1230 (Pregnancy rate).

An interesting question arises at this point, which may be put as follows:

Is the higher average pregnancy rate of these negro women, as compared to the white women, to be accounted for solely because of the lower average weekly income of the negroes, or is there a greater innate fertility among the negro women over and above that associated with lower economic status?

To answer this question we may first substitute the mean weekly income of the negro group in the white equation for the regression of pregnancy rate upon income. This gives:

Predicted pregnancy rate of a group of white women having the same mean weekly income as the negroes in this experience = 13.214 — .0952(20.45) = 11.267 ± .292.

But the observed mean pregnancy rate of the negro group is 15.00 ± .49. The difference between the observed negro pregnancy rate and that predicted for a group of white women experiencing the negro mean weekly income is + 3.73 ± .57. This indicates that the negro women in this sample are significantly more fertile than the white women observed, quite apart from differences in economic status between the two groups.

If we turn the case around and substitute the mean weekly income of the whites in the negro regression equation we shall get a result in the same sense, though less reliable because of the smaller correlation between the fertility and income variables in the negro group. Thus:

Predicted pregnancy rate of a group of negro women having the same weekly income as the whites in this experience = 18.330 — .1628 (29.91) = 13.46 ± .779.

The observed mean pregnancy rate of the white women is 10.37 ± .26. But the negro women, if they had the same average weekly income as the whites would have a probable pregnancy rate 3.09 ± .82 higher than the observed white rate.

As measured by pregnancy rates, the negroes in this experience seem clearly to be innately more fertile than the whites, even after differences in economic status have been eliminated.

Birth Rates and Family Income

Table 4 shows the correlation between the birth rate exhibited by the 581 white women in this sample and family income per week. The birth rate is expressed as number of children ever born (up to the time of record) per each 10 person-years of married life. No deductions for time spent in pregnancy are made in computing exposure to risk in this case, because a woman is plainly exposed to risk of having a baby while she is pregnant, indeed superlatively so.

From Table 4 the following points are to be noted:

1. The distribution of the birth rates experienced by this group of white women is noticeably smoother than the distribution of their pregnancy rates.

2. The biometric constants for the birth rate distribution are as follows (the constants for the weekly income distribution are the same as for Table 2 and therefore need not be repeated):

Birth rate per 10 person-years of married life

Mean ..... $= 4.586 \pm .061$ children
Standard deviation ..... $= 2.189 \pm .043$ children
Coefficient of variation..... $= 47.7 \pm 1.1$ per cent

It will be seen that this group of women had borne children at an average rate a little less than one baby every two years throughout their married lives. This is a high birth rate—far higher than that prevailing at this time in the general population from which this sample was drawn, as has been shown elsewhere.[17]

This group of women exhibits considerably less variability in respect of the birth rates they have experienced than they do in respect of pregnancy rates. The difference between the two coefficients of variation is $88.1 - 47.7 = 40.4 \pm 3.0$. This is evidently a statistically significant difference. The explanation for it is probably partly to be found in the consideration that the occurrence of pregnancy can be rather easily interfered with, both before the event and in the early months after it. On the other hand once a pregnancy has gone beyond three months or thereabouts the regulatory biological processes of the body tend, with relatively little variation, to bring it to a term birth. Only the most drastic external interference will alter this course.

[17] Pearl, R. *Loc. cit.*, footnote 13.

TABLE 4

Correlation Between Income per Week and Number of Children Born per 10 Person-years of Married Life in White Women, in the First Four Years of Experience of the Bureau for Contraceptive Advice, Baltimore

INCOME PER WEEK (DOLLARS)	CHILDREN PER 10 PERSON-YEARS OF MARRIAGE											TOTALS	MEAN BIRTH RATES
	0-.9	1-1.9	2-2.9	3-3.9	4-4.9	5-5.9	6-6.9	7-7.9	8-8.9	10-10.9	12-12.9		
0- 9.99	—	—	1	—	2	1	1	1	1	—	—	7	5.64
10- 19.99	1	6	12	19	16	24	17	5	6	8	1	115	5.27
20- 29.99	9	13	41	30	41	46	35	17	10	8	—	250	4.77
30- 39.99	3	9	14	31	19	19	17	4	2	1	—	119	4.34
40- 49.99	3	4	6	10	5	7	7	3	—	—	—	45	4.14
50- 59.99	2	3	6	4	2	3	2	1	2	—	—	25	3.90
60- 69.99	—	1	1	1	2	—	—	—	—	—	—	5	3.30
70- 79.99	3	—	—	—	—	—	1	—	—	—	—	4	2.00
80- 89.99	1	—	1	1	—	1	—	—	—	—	—	4	3.00
90- 99.99	—	1	1	—	1	—	—	—	—	—	—	3	2.83
100-109.99	—	1	—	—	—	—	—	—	—	—	—	1	1.50
110-119.99	—	—	1	—	—	—	—	—	—	—	—	1	2.50
130-139.99	—	—	—	1	—	—	—	—	—	—	—	1	3.50
190-199.99	—	—	1	—	—	—	—	—	—	—	—	1	2.50
Totals	22	38	85	97	88	101	80	31	21	17	1	581	4.59 ± .06
No information as to income	3	6	11	13	14	13	9	3	2	1	—	75	4.35

3. The coefficient of correlation between birth rate and weekly income calculated from Table 4 is

$$r = -.230 \pm .027.$$

This is in accord in its sense with the finding reached earlier from an examination of the pregnancy rate-income correlation. The birth rate correlation is higher than the pregnancy rate correlation, though by a probably insignificant amount, the difference between the two being $.062 \pm .038$.

4. The regression of births per 10 person-years of married life on weekly income is seen from Fig. 3 *infra* to be clearly linear in its earlier portion and quite smoothly so. In the highest income classes the meagerness of the observations leads to some irregularity.

The value of η for Table 4 is

$$\eta = .248$$
$$\zeta = .0086 \pm .0052.$$

The regression is, therefore, linear.

The regression equations from Table 4 are:

Birth rate $= 5.522 - .0313$ (Weekly income).

Weekly income $= 37.660 - 1.691$ (Birth rate).

It is an open question, so far as the present data are concerned, whether the true regression curve for birth rate on income would be asymptotic at its outer end where the highest incomes occur, as was suggested above in the case of pregnancy rates. Much more extensive observations can alone settle this point.

Table 5 corresponds to Table 4, but gives the data for the negro women in our sample.

The biometric constants for number of children ever born per 10 person-years exposure to married life for these 145 negro women are:

Birth rate per 10 person-years of marriage

Mean	$= 6.160 \pm .101$ children
Standard deviation	$= 1.792 \pm .071$ children
Coefficient of variation	$= 29.1 \pm 1.3$ per cent

The mean birth rate for the negro women in this experience is $1.574 \pm .118$ children per 10 person-years exposure, or about 34 per cent, *higher* than that for the white women. This difference is in the same sense, though not quite so great relatively, as was found above for the pregnancy rates of the two racial groups. The negro women are also less variable in their birth rates than the whites, just as was the

TABLE 5

Correlation Between Income per Week and Number of Children Born per 10 Person-years of Married Life in Negro Women, in the First Four Years Experience of the Bureau for Contraceptive Advice, Baltimore

INCOME PER WEEK (DOLLARS)	CHILDREN PER 10 PERSON-YEARS OF MARRIAGE									TOTALS	MEAN BIRTH RATES
	2-2.9	3-3.9	4-4.9	5-5.9	6-6.9	7-7.9	8-8.9	9-9.9	10-10.9		
0- 9.99	—	—	2	1	1	1	—	—	—	5	5.70
10-19.99	3	—	10	21	16	8	10	—	6	74	6.49
20-29.99	3	4	7	13	11	9	5	1	1	54	6.04
30-39.99	—	1	1	2	—	2	1	—	—	7	6.07
40-49.99	—	1	2	—	—	1	—	—	—	4	5.00
50-59.99	—	1	—	—	—	—	—	—	—	1	3.50
Totals	6	7	22	37	28	21	16	1	7	145	6.16 ± .10
No information as to income	—	2	1	2	—	4	1	1	1	12	6.75

case for the pregnancy rates. The difference here between the coefficients of variation is $47.7 - 29.1 = 18.6 \pm 1.7$, which is statistically significant. Furthermore, just as is the case in the white group, the negro women are significantly less variable in respect of their birth rates than their pregnancy rates, the difference between the respective coefficients of variation being $58.3 - 29.1 = 29.2 \pm 3.3$.

The correlation in this group of negro women between birth rate per 10 person-years of married life and weekly income is

$$r = -.173 \pm .055.$$

Here again we have a negative coefficient confirming the finding for the pregnancy rate correlation in the same group. As weekly income increases the birth rate goes down and *vice versa*. The correlation is, however, lower in the negro group than in the white, as was the case for the pregnancy rate correlation, but by only a statistically insignificant amount, $.057 \pm .061$.

The regression in Table 5 appears to be linear. The observations and the fitted regression lines for the regression of birth rate upon weekly income are shown for both the white and negro groups in Fig. 3.

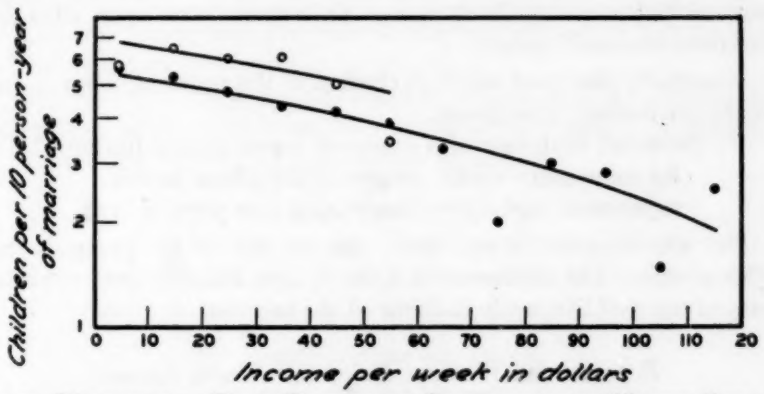

FIG. 3. REGRESSION OF BIRTH RATE PER 10 PERSON-YEARS OF MARRIED LIFE ON WEEKLY INCOME FOR (A) WHITE WOMEN, AND (B) NEGRO WOMEN

Data from Tables 4 and 5. The solid circles are the observed points for whites and the open circles for negroes.

The value of the correlation ratio from Table 5 is

$$\eta = .219$$

$$\zeta = .0180 \pm .0149.$$

The regression is, therefore, linear.

The regression equations from Table 5 are:

Birth rate = 6.992 — .0407 (Weekly income).

Weekly income = 24.96 — .733 (Birth rate).

It is of interest to examine for birth rates the same question that was discussed for pregnancy rates, namely whether the higher birth rate observed among the negro women is wholly to be explained on the basis of their lower economic status, or whether it is in part due to innately superior fertility. Proceeding as before, we have:

Predicted birth rate of a group of white women having the same mean weekly income as the negroes in this experience = 5.522 — .0313(20.45) = 4.882 ± .071.

The observed mean birth rate of the negro group is 6.160 ± .101. That is to say these negro women exhibit a birth rate 1.278 ± .123 children per 10 person-years of married life *higher* than would a group of white women having the same mean weekly income. This result indicates that only roughly about 18 per cent of the observed superiority of the negro over the white group in birth rate is to be accounted for by the difference in economic status between the two groups. Or, to put it the other way about, apparently something over 80 per cent of the observed higher average birth rate of the negroes rests upon other than immediate economic causes.

Essentially the same result is reached if the negro equation is used for the prediction. This gives:

Predicted birth rate of a group of negro women having the same mean weekly income as the whites in this experience = 6.992 — .0407(29.91) = 5.775 ± .159.

But the observed mean birth rate in the white group is only 4.586 ± .061. The difference is 1.189 ± .170 children per 10 person-years of married life, again in favor of the negroes.

Reproductive Wastage Rates and Family Income

The sum total of failures of pregnancy to result in the birth of offspring at term in a group of breeding women may be regarded as the *reproductive wastage* of that group. Such failures may be due to any of a variety of causes, such as induced abortion, spontaneous abortion or miscarriage, disease, etc. For the purposes of the present investigation all such failures, regardless of their causes, are taken together as a single group. The first interest of the student of population

problems is the total magnitude of reproductive wastage. Its underlying causes present a separate and distinct problem, or series of problems. In the present paper we shall not concern ourselves with these problems, but consider the total reproductive wastage without regard to its causes. The relation of this variable to family income per week in the case of our sample of white women is shown in Table 6. In this table reproductive wastage is expressed as a rate. This rate is taken as

$$\frac{(\text{Abortions and/or miscarriages}) \times 100}{\text{Pregnancies}}$$

That is, we have determined for each woman in the experience the reproductive wastage per 100 pregnancies in which she was at risk. The term "abortion" will be used, for verbal convenience, to include all terminations of pregnancy, from whatever cause, prior to full term (or so near full term that a viable child is born). Thus spontaneous abortions (or miscarriages), induced abortions, etc. are all included in the single term "abortion." This is in accord with the accepted usage of obstetricians at the present time.

The totals of Table 6 do not agree with those of Tables 2 and 4, because there were 10 white women in the sample, who, though living in wedlock, had never been pregnant at the time of record, and therefore had not been exposed to risk of an abortion.

The biometric constants for Table 6, excluding from consideration the last line where there is no information as to weekly income, just as in all the other tables in this paper, are as follows:

Abortion Rate

Mean ..... = 17.83 ± .58 per 100 pregnancies
Standard deviation ..... = 20.42 ± .41 per 100 pregnancies
Coefficient of variation.... = 114.5 ± 4.4 per cent

Family Income per Week

Mean ..... = $29.61 ± .45
Standard deviation ..... = $15.92 ± .32
Coefficient of variation... = 53.8 ± 1.4 per cent

It is thus seen that the mean reproductive wastage in this group of highly fertile women is approximately 19 per cent. Dickinson and Beam [18] report (p. 258) that out of 703 women who were ever pregnant

[18] Dickinson, R. L. and L. Beam. A Thousand Marriages. A Medical Study of Sex Adjustment. *Baltimore* (Williams and Wilkins Co.) 1931.

in their series, there were 1915 pregnancies, of which 1348 were carried to term and 567 aborted. This gives a reproductive wastage of 29.6 per cent. These women belonged, on the average, to much higher social and economic classes than those in the present series.

On the other hand, from Table X (p. 10) and Table III (p. 18) of Davis'[19] report on her questionnaire study of 1000 married women it is possible to gather the following data: 991 women in this series reported having had 1726 children in total (Table X), while 985 women reported having had 2258 pregnancies. Disregarding the discrepancy of six women not reporting pregnancies who did report births, these figures give a reproductive wastage in the Davis sample of roughly 22 per cent. This figure is still somewhat higher than that for the present series, but nearer to it than to the Dickinson and Beam result.

Around 20 per cent is the value usually assigned for the reproductive wastage in legitimate pregnancies in countries of generally advanced civilization. Thus, in a recent discussion of the whole subject, Handman[20] quotes (p. 373) Bertillon (though without precise reference) to the effect that the proportion is 19.3 per cent in France. Prinzing,[21] in a chapter devoted to the subject, gives figures from various sources ranging from around 10 per cent to more than 20 per cent.

The degree of individual variation among the white women composing the present sample is clearly very high in respect of reproductive wastage, as measured by the coefficient of variation.

So far as this sample of white women is concerned there is no correlation between reproductive wastage and economic status, within the group. The coefficient of correlation calculated from Table 6 is

$$r = +.00242 \pm .028$$

an obviously insignificant value. The value of η is also not significantly different from zero, being

$$\eta = .133$$

while the mean value of η in samples of this size from a population in which η is actually zero is .151.

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[19] Davis, Katherine B. Factors in the Sex Life of Twenty-two Hundred Women. *New York* (Harper and Bros.) 1929.

[20] Handman, M. S. Article "Abortion." *Encyclopedia Soc. Sci.*, Vol. I, pp. 372-374, 1930.

[21] Prinzing, F. Handbuch der medizinischen Statistik. Zweite Auflage. *Jena* (Fischer) 1931.

TABLE 6

Correlation Between Income per Week and Number of Abortions per 100 Pregnancies Experienced by White Women, in the First Four Years Experience of the Bureau for Contraceptive Advice, Baltimore

INCOME PER WEEK (DOLLARS)	ABORTIONS PER 100 PREGNANCIES										TOTALS
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-100	
0- 9.99	4	1	1	1	—	—	—	—	—	—	7
10- 19.99	66	11	7	9	11	4	3	2	1	1	115
20- 29.99	146	18	28	19	11	14	4	4	1	3	248
30- 39.99	66	14	17	7	2	7	2	1	—	1	117
40- 49.99	27	2	5	1	3	3	1	—	—	1	43
50- 59.99	13	3	3	3	—	—	—	—	1	—	23
60- 69.99	3	—	—	1	—	1	—	—	—	—	5
70- 79.99	1	—	—	—	—	—	—	—	—	1	2
80- 89.99	2	—	1	—	—	—	—	—	—	1	4
90- 99.99	2	—	—	—	—	1	—	—	—	—	3
100-109.99	1	—	—	—	—	—	—	—	—	—	1
110-119.99	1	—	—	—	—	—	—	—	—	—	1
130-139.99	—	—	1	—	—	—	—	—	—	—	1
190-199.99	1	—	—	—	—	—	—	—	—	—	1
Totals	333	49	63	41	27	30	10	7	3	8	571
No information as to income	41	3	8	6	2	8	1	1	3	2	75

Table 7 shows the correlation between the same two variables, reproductive wastage and weekly income, among the negro women in this experience.

TABLE 7

Correlation Between Income per Week and Number of Abortions per 100 Pregnancies Experienced by Negro Women, in the First Four Years Experience of the Bureau for Contraceptive Advice, Baltimore

INCOME PER WEEK (DOLLARS)	ABORTIONS PER 100 PREGNANCIES								TOTALS
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	
0- 9.99	2	2	—	—	1	—	—	—	5
10-19.99	55	4	7	4	1	2	—	1	74
20-29.99	32	8	7	3	1	3	—	—	54
30-39.99	3	1	—	2	—	—	1	—	7
40-49.99	2	1	1	—	—	—	—	—	4
50-59.99	—	—	1	—	—	—	—	—	1
Totals	94	16	16	9	3	5	1	1	145
No information as to income	9	1	—	—	—	1	1	—	12

The biometric constants for the reproductive wastage distribution of Table 7 are as follows:

Abortion Rate per 100 Pregnancies

Mean ..... = 13.12 ± .82 abortions
Standard deviation ..... = 14.65 ± .58 abortions
Coefficient of variation..... = 111.7 ± 8.3 per cent

The most noteworthy point brought out by these values is the markedly lower mean reproductive wastage rate in these negro women as compared with the whites of Table 6. The mean abortion rate is 4.71 ± 1.01 points lower in the negroes than the whites, a difference of roughly 26 per cent of the white value. Plainly in this material the negroes are biologically more efficient reproductive machines than the whites; they have, on the average, (a) significantly higher pregnancy rates, (b) significantly lower reproductive wastage rates, and by necessary consequence of (a) and (b) significantly higher birth rates.

The variability of the reproductive wastage rate is about the same in the negroes as in the whites in this material.

While numerically somewhat larger than the corresponding figure for the whites the coefficient of correlation in the negro group between

weekly income and reproductive wastage cannot be regarded as significantly different from zero, having regard to its probable error. The value is

$$r = +.117 \pm .055.$$

The value of the correlation ratio η is

$$\eta = .193$$

while the mean value of η in samples of this size from a population in which η is actually zero is .186.

It has been seen that there is no significant intra-group (inter-individual) correlation between economic status as measured by weekly income, and reproductive wastage, as measured by abortion rate, in either the white or negro groups, in this material. It has been shown earlier,[22] that in this same material the abortion rate rises as the pregnancy rate rises. That is to say the number and the percentage of abortions experienced by a woman tend to increase with the number of pregnancies she has. This is furthermore in accord with general experience on the point.[23] But an inter-group comparison in the present case leads to the paradoxical result that while the negro women exhibit a significantly higher mean pregnancy rate than the whites, they show at the same time a significantly lower mean abortion rate. It seems possible that the differences in social and economic conditions between the two racial groups may have some part in the causation of this paradoxical situation, in spite of the fact that neither group, taken by itself, shows any significant inter-individual correlation between economic status and reproductive wastage. But I know of no positive evidence to bring forth in support of this possibility, unless the higher reproductive wastage rate shown by Dickinson's and Beam's sample of women (cited above), belonging to a higher social and economic level than the white women of the present material, might be so interpreted. I should, however, hesitate to make such an interpretation; certainly no weight could be attached to it, in the present state of ignorance of the causal factors involved in so-called spontaneous abortions. Of course the alternative explanation of the negro-white paradox is that it expresses innate biological differences between negroes and whites in their physiology of reproduction. This may be the fact. Any evidence now existing is inadequate to settle the point.

[22] Pearl, R. *Loc. cit.*, p. 7, footnote 8.
[23] Prinzing, F. *Loc. cit.*, p. 49, footnote 21.

SUMMARY

This paper presents some data concerning some aspects of differential fertility, which is a major element in the general problem of population. The data are derived from the first four years of experience of the Bureau for Contraceptive Advice in Baltimore, and are based upon the complete and carefully recorded reproductive histories of 581 white and 145 negro women, referred by physicians to the Bureau in order that they might be instructed and advised regarding contraception.

It is shown that:

1. These women have experienced during their lives a higher pregnancy rate than comparable samples of women from the general population.

2. Within these groups, both white and negro, there is found to be (a) a small but statistically significant negative correlation between economic status (as measured by family income in dollars per week) and pregnancy rate (as measured by number of pregnancies per 10 person-years exposed to risk of pregnancy), and (b) a similar negative correlation between economic status and birth rate (as measured by number of children born per 10 years of married life).

These correlations mean that, within this material, those women with relatively higher weekly family incomes tended to have relatively fewer pregnancies and fewer children than those women with relatively lower weekly incomes.

3. The negro women in this material, as a group, exhibited significantly higher mean pregnancy and birth rates than the white women, as a group, and had a lower mean weekly income. But the higher mean pregnancy and birth rates of the negro women in this material are only in part capable of being accounted for by the observed differences between the two groups in economic status. The observed reproductive differences between the two racial groups appear to be mainly expressions of innate biological differences rather than of any effects of environmental factors.

4. Neither the white nor the negro women in this material show statistically any sensible intra-group (inter-individual) correlation between economic status and rate of reproductive wastage (as measured by the number of abortions and/or miscarriages per 100 pregnancies). Within each group the reproductive wastage rate was substantially the same for the women with relatively higher weekly incomes as it was for the women with relatively lower weekly incomes.

5. The negro women in this material, as a group, show statistically a significantly lower mean reproductive wastage rate than the white women, as a group, in spite of their higher fertility.

6. In this material the negro women, as a group, appear to be clearly more efficient reproductive mechanisms than the white women, as a group, when considered from any or all of the three aspects of the matter here dealt with, namely pregnancy rate, birth rate, and reproductive wastage rate.

NOTES

ON THE PRIORITY OF THE BIOLOGICAL HEREDITARY LAW OF "ANTICIPATION"

In the February (1932) issue of HUMAN BIOLOGY, was published a paper under the title: "The relation of the mode of inheritance to the severity of an inherited disease," by Madge Thurlow Macklin, in which there is the following passage: "The Law of Anticipation. A generalization noted in the study of inherited diseases was made years ago, nor am I able to say just who was responsible for it, although I myself first found it referred to in the writings of that great student of human inheritance in eye defects, Edward Nettleship. He designated it as the law of anticipation, meaning that a disease which was inherited in the direct line of descent tended to appear at an earlier age in the children than it did in the parents."

Mrs. Macklin having been asked to which of Nettleship's works the above quoted passage referred, kindly answered that she could not possibly tell as "the books containing this passage had been lent to her and she was not able to consult them again."

For my part I have found that Fleischer and Josenhans,[1] writing in the year 1920 on the disease of Leber (who was the first to describe in 1871 the familiar hypertrophy of the optic nerves) and referring to Nettleship and to anticipation, mention 1909 as the date at which the latter dealt with the subject of anticipation in Leber's disease. ("Die Ansicht von Nettleship[2] dass *das Leiden die Tendenz habe, in späteren Generationen in früheren Alter aufzutreten,* hat sich hier nicht bestätigt.) In the bibliography collected by the two Germans no other publication by Nettleship is mentioned.

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[1] B. Fleischer u. W. Josenhans. Ein Beitrag zur Frage der Vererbung der familiären Sehnervenatrophie (Leberscher Krankheit). *Archiv für Rassen—u. Gesellschaftsbiologie,* Bd. 13, H. 2—4. 1920.

[2] Nettleship. On some hereditary diseases of the eye. *Transactions of the Ophthalmological Society of the United Kingdom.* 1909. Bd. XXIC, S. LVII.

I have also observed that R. Kawakami, in a paper [3] in which Nettleship is mentioned for his studies on Leber's disease, quotes several old and recent cases, but remembers Nettleship only on account of his work of 1909.

Then if we consider that the study of the two Germans belongs to the year 1920, and the work of the Japanese to the year 1926, we are indeed in the position to know almost completely the literature on Leber's disease; in all this literature only one of Nettleship's works is mentioned, and always the one of 1909. In more recent publications, such as Terrien's paper of 1929 [4] no allusion is made to Nettleship.

It seems thus evident that Nettleship's work quoted by Mrs. Macklin, must be the above mentioned one of 1909. In such case, and this is the point that I wish to make, the priority owed to me for the statement of the phenomenon of "anticipation" in the appearance of hereditary diseases in the members of succeeding generations remains unchanged. This conception, which I supported and illustrated in 1901 [5] basing myself on a large number of cases collected in 1900, was in contrast with the conception of "homochronicity" which had been predominant up to that time.

It was that first communication of mine which gave birth in Italy [6] to several publications, the results of which completely confirmed the principle supported by me.

In the last 25 years many references to the above mentioned law (especially in the articles of psychiatric periodicals concerning the subject of heredity in general) have appeared also in foreign countries and particularly in Germany. It is also true, however, that the Italian works are never mentioned and my own original communication even less.

From time to time, on the contrary, we see that somebody discovers again this circumstance of anticipation and spreads it round not only as a new thing, but even as an exception to the rule of homochronicity that I proved non-existent as early as 1901. Thus recently during a meeting

[3] R. Kawakami. Beiträge zur Vererbung der familiären Sehnervenatrophie. *Graefes Archiv für Ophtalmologie*, B. H. 1926, 568.

[4] F. Terrien. Les Atrophies optiques congénitales et infantiles. *Le Progrès Médical*, N. 105. 1929.

[5] A. Pieraccini. Ulteriore contributo alle leggi che regolano la ereditarietà psicopatica. *Atti del II Congresso Freniatrico, Ottobre 1901. Rivista sperimantale di Freniatria. Reggio Emilia*, 1901.

[6] Alessandrini frequently. Bergamasco. Manzoni and the A; A; referred to.

of the *Société Médico-Psychologique* of Paris [7] the fact of a hereditary disease appearing earlier in the heir than in the fore-father, has been defined as a "strange mode of morbid heredity."

In reality, however, the phenomenon of "anticipation" is not given that importance which, according to my opinion, it deserves, and which should be attributed to it in the speculative as well as in the practical field.

From this point of view it is enough to remember the conclusions which I attained in 1901 and which have been fully confirmed and strengthened by C. Pieraccini,[8] who resumes them in the following way:

1st. There is a biological law according to which in a family circle, in the appearance of mental disorders, we have anticipation for the members of succeeding generations. Such a fact must be considered almost constant in the general practice.

2nd. The basis of the rule of anticipation in persons of the same family but of different generations may be stated thus: for the grandson of an insane grandfather the greatest danger of meeting the same fate of his direct forefather takes place when his own age is forty years less than that at which the grandfather fell ill. As for the child of an insane father or mother the greatest danger proves to be when his own age is 25 years less than that at which his father or mother was struck by the disease. This danger diminishes both for sons and grandchildren as they draw near the age at which their parents and grand parents became insane, and all danger can be considered over when the age of the descendants has overtaken that age at which the predecessor fell ill. As for the nephews of insane uncles the greatest danger of going mad exists when the descendants' age is at 24 years' distance from that at which the elder relative fell ill. This danger continues to diminish as the nephew's age approaches the age when the uncle fell ill, and becomes negligible once that period is past.

From the theoretical point of view, the element, anticipation of generation, together with the element, anticipation of birth [9] lends itself to hereditary-biological speculations of a general kind, the importance of which will not fail to be appreciated by everybody, especially as it seems that the phenomenon of anticipation can be observed also in cases

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[7] *Annales Med-psychologiques*, Juillet, 1930, Paris.

[8] C. Pieraccini. Di alcuni elementi di fatto, tratti da pazzi consanguinei ospitalizzati, per lo studio delle leggi che regolano le ereditarietà psicopatica. *Rassegna di studi Psichiatrici*. Fasc. 6, Vol. XIV, Novembre-Dicembre 1925, Siena.

[9] C. Pieraccini. *Atti del Congresso Soc. Freniatrico it., Ferrara*, 1930.

of suicide [10] and that it certainly takes place in some diseases of the nervous system [11] and of the organic exchange.[12]

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[10] C. Pieraccini. *Idem.*

[11] G. Pieraccini. L' anticipazione nelle malattie eredo-familiari. II *Congresso di genetica ed eugenica, Roma,* Settembre-Ottobre, 1929.

[12] G. Pieraccini. La Stirpe dei Medici di Cafaggiolo. *Firenze. Vallecchi.* 1925.

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QUOTATIONS

TOBIAS VENNER AND HIS VIA RECTA[1]

BY RAYMOND PEARL

INTRODUCTION

Anyone who delves into the literature of longevity presently comes upon references and allusions to a remarkable book, the *Via Recta ad Vitam Longam,* written by one Tobias Venner "Doctor of Physick in *Bathe,*" and first published in 1620. While this book is in no way a great bibliographic rarity,[2] it is nevertheless scarce enough to fetch rather rapidly mounting prices with each successive appearance in the market. Perhaps this is due partly to the fact that it is also one of the bibliographic landmarks in another and more popular field of interest than longevity, namely gastronomy. All collectors of the literature of cooking and eating must have it. In its day the *Via Recta* had a considerable popularity. A second edition appeared in 1622. In 1623 an additional second part of the *Via Recta* was published. This was incorporated into the later editions, or reprintings, of 1628, 1638, 1650, and 1660. In fact it was the practice of the author, as long as he lived, to incorporate into this book, everything else he wrote for publication. This resulted in the final (1660) edition containing really three different books or pamphlets originally published separately: *viz.,* (1) the *Via Recta* expanded, (2) *The Baths of Bathe,* with two Appendices, and (3) *A Brief and accurate Treatise concerning . . . . . Tobacco.*

Regardless of the titles under which he published his ideas what Venner wrote about was the subject now called personal hygiene. And he wrote, on the whole, soundly and well. Indeed the latest treatise on personal hygiene of to-day contains little of any importance that is

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[1] From the Department of Biology of the School of Hygiene and Public Health, Johns Hopkins University.

[2] The Surgeon General's Library, however, has no copy of any edition. The only work of Venner's in that library is a copy of the first edition of his *Tobacco* treatise.

not in the *Via Recta* in one form or another, or little advice that differs in any essential way from old Dr. Venner's. To be sure he tricked out his precepts with the orthodox Hippocratic and Galenical rationalizations of his time. The modern hygienist is, of course, not concerned with any such antiquated ideas as "temperaments." Instead he has a nice new, up-to-date set of rationalizations all his own. This is as it should be. Man's explanations of enduring realities have always been singularly ephemeral. To achieve success theory must be in step with the general thought of its time. In fact about the only actually used realistic test of the validity of any theory is its popularity. So long as the bulk of mankind think a theory is valid, it is so for all practical purposes. Witness the Newtonian theory of gravitation prior to Einstein.

The *Via Recta* has interest not only as an early and comprehensive treatise on personal hygiene, but also for the light which it throws upon the intimate habits of life of the people in the England of Elizabeth, James I, Cromwell, and Charles I. Venner was a thoroughly logical person. When he set out to discuss the hygienic significance of foods he listed *all* the foods that anybody ate, so far as he knew, and discussed them *pro* and *contra*, one by one. Consequently we can reconstruct from it a more adequate picture of the family meals in late 16th and early 17th century England than from any other source known to me. Hazlitt[3] devotes considerable space in his delightful treatise on cook books to the *Via Recta*, and writes Venner down as "evidently a very intelligent person." He was all of that.

I propose to discuss the book here under three general heads: First, the author; second, the description of the book; and third, specific illustrations by quotation of what it says on various topics.

THE AUTHOR

Tobias Venner was born "of honest parents" at Petherton, near Bridgewater in the southern part of Somerset, in 1577 and died at Bath on March 27, 1660.[4] At the age of 18, Venner matriculated from St. Alban Hall, Oxford, took his B. A. degree on Feb. 1, 1598-9, and his M. A. in 1603. He then, at the age of 26, set up in the practice of

[3] Hazlitt, W. C. Old Cookery Books and Ancient Cuisine. *London* (Elliot Stock), 1902.

[4] Pollard, A. F. *D. N. B.*, Vol. 20, pp. 212-3. No full length biography of Venner appears to have been published.

medicine in his native town. Ten years later, on March 31, 1613, Oxford granted him the M. B. and M. D. degrees, with "a certificate from the regius professor of medicine that he was fit for these degrees, a dispensation for non-attendance on the professor's lectures, and a grace in convocation which relieved him of the necessity of waiting over four congregations for the degrees (*Reg. Univ. Oxon.* II. i. 34, 125, 126, 128.)"[5]

Thus equipped with degrees and experience Venner began to extend the range of his practice, particularly to Bridgewater and Bath in the northern part of the county. He presently took to living in Bath during the spring and autumn months. These were the seasons of heavy inflow of visitors seeking the cure. Venner eventually came to have a large and lucrative practice, in good part due, it is said, to the popularity of his *Via Recta*. But this could hardly have been the major factor. There is much internal evidence in his writings to show that he must have been an unusually able, sound, and conservative practitioner of just the kind to attract and hold the highest class of patients. The following passage from *The Baths of Bathe* (pp. 353-4) indicates his attitude regarding the ethics of his profession.[6]

But seeing that no calling is more disgraced, than by the men of the same calling, I wish all such as are Graduates in the faculty of Phisick to carry themselves worthy of their calling, to be faithfull and honest in their courses, not to insinuate with any, or after the manner of our Bath-guides, presse upon them to be retained. If an Emperick or Mountibank seek about for work, I blame them not; let them deceive those who will be deceived; but for such as are graduated in the noble faculty of Physick to do so, it is Fidler-like: a note, if not of some unworthinesse in them, I am sure, of a base mind. Let those therefore that are *P*hysicians indeed, strive to maintaine the reputation of their Art, and not by a base insinuating carriage, or Mountibank-like tricks, or detracting others of their owne faculty, to get a note and repute, vilifie their owne worth, or disgrace so noble a Faculty.

To cure diseases is beyond the sole power of sinfull man, therefore those Physicians *perfricta fronte*, do audaciously erre, that Mountiback-like (I wish that our City of *Bathe* were at all times free of such) arrogantly warrant the cure of any disease, though never so desperate and incurable; but let me tell you that these are such *P*hysicians and Impostors as aime at your purse, that will sell their soules for money: and therefore suffer not your selves to be cheated and deluded by them; for, when by their Spaniel-like fawning carriage, & warrant-

[5] Pollard, *loc. cit.*, p. 212.

[6] In this and the following quotations in this paper I have transcribed Venner's spelling and punctuation exactly. But for obvious reasons I have replaced the cursive *s* of his time with the ordinary letter of our day.

izing Promises they have well div'd into your purse, they will send you away with some triviall medicines, putting you in hope of health afterwards. But it is strange to see how vainely very many of our people are carried away, befooling themselves with such vaine and arrogant promises, especially if the Mountibank-like Doctor shall be outlandish (*salvo doctiorum & honestiorum honore*) wherein they bewray much levity and want of judgement.

How little the technique of quackery and the dependable gullibility of the public, on which its success rests, have changed in three centuries!

Venner's portrait by Faithorne, which forms the frontispiece of the final (1660) edition of his writings is reproduced here as Fig. 1.

The nearest to a contemporary account of Venner's life is that contained in Thomas Guidott's *Lives and Characters of the Physicians of Bathe,* dated 1677, but published with his *Discourse of Bathe,* 1676.[1] This is only sixteen years after Venner's death. Guidott's

The title-page of the whole book is:

[Within two single rules] A / DISCOURSE / OF / BATHE, / AND THE / HOT WATERS There. / ALSO, / Some Enquiries into the nature of the / Water of St. *Vincent's* Rock, near *Bristol;* / and that of *Castle-Cary.* / To which is added, / A Century of Observations, more fully de- / claring the Nature, Property, and distinction of / the BATHS. / WITH / An Account of the Lives, and Character, of the / Physicians of *Bathe.* / [single rule] / By *THO. GUIDOTT,* M.B. / Physician There. / [single rule] / *Virtute vincam Invidiam.* / [single rule] / *LONDON,* / Printed for *Henry Brome* at the *Gun* in St. *Paul's* / *Church-yard,* the West end, 1676. /

The separate title-page of *The Lives and Character,* which is folio M8[a], p. [159] of the whole book, is as follows:

THE / LIVES / AND / CHARACTER / OF THE / PHYSICIANS / OF / BATHE, / From the Year, MDXCVIII. / To this present Year, MDCLXXVI. / In which, / Within the compass of Fourscore / Years, is comprehended great part of the / Lives of XVII. Physicians, which confirms the words / of *Hippocrates,* in his first *Aphorism;* / *Ars Longa, Vita Brevis.* / [single rule] / By *T. G.* M.B. / [single rule] / *LONDON,* / Printed for *Henry Brome,* MDCLXXVII. /

biography of Venner must surely be regarded as one of the meanest and nastiest pieces of sly scurrility ever written about a good and distinguished man after his death. It is not long and I propose to quote it

[1] The transcriptions of the title-pages of these two works, which were issued together in one continuously paged volume, are as given below. In making these transcriptions I worked with the copy in the Surgeon General's Library in Washington, and desire to express my grateful appreciation of the courtesies extended by the officials of that library.

FIG. 1. FACSIMILE OF THE FAITHORNE PORTRAIT OF DR. VENNER

in full so that a later generation may see exactly what manner of man Guidott was.

Thomas Guidott was born at Lymington, Hampshire, in 1638. He went to school at Dorchester, and was a commoner of Wadham College, Oxford, where he was given the B. A. degree in 1656, and the M. A. in 1662. He was admitted M. B. in 1666 and practiced in the neighborhood of Oxford for a time. In 1667 he moved to Bath, where for awhile he had a large practice; but by 1679 he had lost most of it because of his "impudence, lampooning, and libelling." Gordon Goodwin,[8] in his account of Guidott's life upon which I have drawn for this note, quotes Wood and Hearne to the effect that he was " 'a person of good parts, well vers'd in Greek and Latin learning, and intelligent in his profession; but so much overwhelm'd with self-conceit and pride as to be in a manner sometimes crazed, especially when his blood was heated by too much bibbing' (*Athenae Oxon.* ed. Bliss, iv. 733-5). Hearne calls him 'an ingenious, but vain, conceited, whimsical physician' (*Collections,* i. 123, Oxf. Hist. Soc.)." He was a very prolific writer, chiefly of tracts touting the advantages of the Bath waters.

His account of Venner begins on p. 168 of the *Discourse* cited above and runs as follows:

6. Doctor *Tobias Venner*

Doctor *Tobias Venner* was born at Petherton near *Bridgewater* in the County of *Somerset,* of honest parents, who sent him to *Oxford,* where he was made Doctor in Physick to the great repute of his own family, and *Alban Hall,* in the year 1613. He lived many years at *Bathe,* and had the Name of a plain, charitable Physician, but no ready man at stating a Case, which occasion'd one, a little tartly, to say, *That whereas some other men had,* (according to the common Phrase) *Guts in their Brains;* Dr. Venners *Brains were in his Guts.* However he found the right way to write a book called *Via recta ad vitam longam,* wherein is this memorable Observation, *That a Gammon of Bacon is of the same nature with the rest of the Hog.* He wrote also a little discourse of *Bathe,* thereby expressing his good will to the Waters, which had it been bigger he should have had more thanks, but being very small, must be contented with the like commendation.

He lived to see both his Wives, and all his Children die before him, and left his Estate to the Relations by his second wife now in *Bathe*:

The Ashes of this grave,
No Phoenix, but Chimaera gave, *A Riddle*
The Head, the Feet, about the Thigh,
A Duck, a Mouse, a Butterflie.

I can give no better account of him than a Friend of his hath done in this *Epitaph,* to be seen engraven in a Marble Table, in the middle of a massie Monu-

[8] Goodwin, G. *D. N. B.,* Vol. 8, pp. 765-6, 1890.

ment of Freestone against the East Wall of the South Isle, in the greatest Church of *Bathe*, under his Effigies in this manner.

SISTE VIATOR
PAUCIS TE VOLO
JUXTA HIC SITUS EST VENNERI VENERANDUS CINIS
INTER MORTUORUM CLAUSTRA MORTUUS JACET
MAGNUS MODO MORTIS ANTAGONISTA
DOCTOR ET DECOR MEDICINÆ
CUJUS SUPERBIAM NON FORMIDIBANT ÆGRI
UTI NEC CONCULABANT FACILITATEM
AUXILIUM ENIM
NEC SORDIDE OBTULIT
NEC FASTIDIOSE NEGAVIT
IN HOC CONVERSATIONIS SAUVITATI
IN ILLO PROFESSIONIS DIGNITATI
PROSPICIENS
PAUPERUM ET DIVITUM MEDICUS
HORUM QUOD MEDICINAM
ILLORUM QUOD CHARITATEM
SOLUS HIC TAMDIU EXERCUISSET
HORUM QUIDEM OMNIUM APPLAUSU
ILLORUM CIVITATIS HUJUS DELECTU
NEC PLUS DEFUIT SANIS QUAM ÆGRIS PAUPERIBUS
MANU NON PARCA EXHIBIENS
HIS MEDICINAM
ILLIS ALIMONIAM
VIAM RECTAM AD VITAM LONGAM
NON MONSTRAVIT MODO SED ET PERAMBULAVIT
THEORIAM UNIUS ANNI CONFIRMANS PRAXI 85
TANDEM ITINERANDO DEFESSUS DISCUBUIT
ET IN HOC DORMITORIO OBDORMIT
GRATA MEMORIA DIGNISSIMUS
DOCTOR TOBIAS VENNER
QUI
NATUS PETHERTONIÆ
EDUCATUS OXONIÆ
OBIIT BATHONIÆ
MART. 27
1660[9]

[9] The sense of the occasionally tricky Latin of this epitaph is as follows, unless my construing is at fault. Miss Hermine Grimm and I have endeavored to turn

The Author of this Epitaph, for who made it is uncertain, seems rather to me to have been a Divine rather than a Physician, for which conjecture I have these Reasons:

1. That the form thereof is borrowed from one made on Doctor *Daniel Featley*, now in *Lambeth*, as I could clearly make appear by comparing the Expressions, as I have sometimes done, and for the satisfaction of any that desire it, may without a journey thither, be read, *mutatis mutandis*, in Doctor *Featley's* Book against the Anabaptists, where it is copied, and whence it was probably taken. Now a Physician, I conceive, would never have taken pattern from a Divine, to make an Epitaph on his own Faculty, which is proper for a Divine, being more his concern.

2. *Venerandus* is a word suiting better with a Divine, and a more proper Epithete than for a Physician, as *Reverandus* & *Venerabilis;* and is most likely to come from one whose tongue was tipp'd with such language, who would rather chuse to run the risque of an impropriety in speech, than lose the honour of a jingling quibble.

3. 'Tis probable this Epitaph was made near a Church, and that either when the Bells were going, or else in imitation of that sound, as may appear from the Chime of *Hoc* and *Illo, Horum* and *Illorum, His* and *Illis,* with the great pains taken to observe the Cadences so exactly as is done.

4. In the fourth place, the word *plus* is somewhat suspicious, by which we must understand *minus,* otherwise, *Nec plus defuit sanis quam ægris pauperibus,* may bear this sense, and not well any other, *that the Doctor was wanting both to the one and the other,* when the Author, I suppose, meant *he was wanting to neither.* Now *Plus* is a fit word for a divine, and might the sooner have been made choice of for this, that 'tis the origin or sourse of the word *Plurality.*

Fifthly and lastly; No Physician would have used that Expression, *Theoriam unius anni confirmans Praxi* 85, by which Doctor *Venner* is made a Practitioner

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it into equivalent English idiom rather than to give a strictly literal translation of each Latin word.

Pause, wayfarer. I want you for a few moments. Hard by this spot Venner's ashes are to be venerated. Amid the tombs of the dead he who was lately a great fighter of death himself lies dead: a doctor of medicine and a distinction to the profession, before whose lofty spirit the sick were unabashed and yet did not abuse his affability. For he did not proffer his aid stingily or deny it scornfully. Suave in discourse he none the less maintained the dignity of his profession. Far-seeing physician to the poor and the rich alike, no one has dispensed charity on the one hand and healing on the other for so long a time in this place as he has. Applauded by all he was our chosen leading citizen. He was not found wanting by either the well or the sick poor; with no sparing hand he dispensed sustenance to the one and medicine to the other. He has not only set forth in one year the theory of the right way to attain great longevity, but has established its soundness in practice by living 85 years himself. Then weary of the grind of doing he lay down, and in this dormitory sleeps in death. Held in grateful memory, the most worthy Doctor Tobias Venner, who was born in Petherton and educated at Oxford, died in Bath on March 27, 1660.

from his Mother's womb, and longer a Physician than St. *John Baptist* was a Prophet, which in it self being somewhat harsh, though taken in relation to his course of life, where the life of that expression lay, can proceed from none but a Divine, who oftentimes will be nibbling at Physick.

Again, for I reserved something for a second part, That expression is justly liable to exception, *Quod Charitatem solus hic tamdiu exercuisset*, wherein Dr. *Venner* is made the only Charitable person in *Bathe*, whereas there were then living, besides some Charitable Inhabitants of another stamp, three or four more Physicians there, whose Charity, though perhaps not so rampant as Dr. *Venners*, was enough in both food and Physick to call the truth of that expression into question.

And although this necessary requisite to every good Christian that is in a condition to do so, be not with that ostentation put into the Epitaph of Dr. *Bane*. Yet I have heard a good character of him also in this kind, and do know many poor persons now alive in *Bathe*, that will affirm they have received good Alms and Physick too from his Charity. I confess *Tamdiu* may do some service here, to this effect, that Dr. *Venner* was the only man that was charitable here so long, which, though it may abate somewhat, does not take off the arrogance of *Solus*, which, like the Sun, never appears without reflection. I write not this to derogate from Dr. *Venner*, or disparage the Epitaph, having that esteem for both they do deserve; but as the Devil, we say, should have his due, so I think, 'tis not fitting a Saint should have more. And thus much for the charitable Dr. *Venner*.

This biography so reveals the character of its author as to require no comment from me, save in regard to his animadversions upon the epitaph. Points 1, 2 and 3 of Guidott's commentary may be dismissed as merely silly spleen. Point 4 is no more than pettifogging pedantry. The intended meaning of the epitaph writer is as plain to Guidott as it is to anybody else. Point 5 is more important. It casts a slur indirectly upon Venner's professional ethics. But Guidott has completely missed the point the epitaph writer makes in this sentence. The idea intended to be conveyed, and what the Latin actually, if somewhat clumsily, says is that while in a single year Venner wrote a book [the *Via Recta ad Vitam Longam*] preaching the hygienic theory of the way to live long, he put his preaching into personal practice by himself living to the ripe old age of 85. The *praxi* has no more to do with the practice of medicine than my grandmother's cat had with metaphysics. It is "practice" contrasted with "preaching."

In his commentary on *solus* Guidott was plainly dishonest, because what he says about *tamdiu* shows clearly that he really understood what the epitaph writer meant here, which was merely that Venner had been longer engaged in the practice of good works in Bath than any other physician of whom there was knowledge at the time. But

even though he completely apprehended the meaning of the epitaph on this point, and knew it was true, he chose to befog the matter and give the good old Doctor one more dirty dig.

And thus much for the stercorary Mr. Guidott.

So far as may be judged from his own writings and from the little that is elsewhere recorded about him, Venner's character may be summarized as that of a highly intelligent, conservative, successful medical practitioner. He was, overtly at least, a devoutly religious man, but not wholly lacking in a sense of humor. It has been contended that he was a bit of a snob and I am disposed to think that it cannot be denied, though I believe that Hazlitt (*loc. cit.*) over-emphasizes this trait. After all, the rich buttered Venner's bread, and what could be more likely than that fact to sharpen his perception of their virtues, taken as a class? Furthermore it is not to be overlooked that he was professedly writing his book for them. Thus he says in disapproving of black puddings (*Via Recta*, p. 100):

> . . . they yield a naughty, feculent and obstructive nourishment, and fill the body with wind: and therefore I could wish that dish, which is commonly the first, to be casheered from the Tables of them, for whom I write this Treatise, and to be exhibited to the poor, and to agrested bodies that commonly digest anything that filleth the belly.

Venner's standing in the community of Bath is in some sense independently indicated by the very fact that the "massie monument of freestone" with an effigy was erected in his memory in St. Peter's Chureh. Pepys [10] makes special mention of seeing it on June 14, 1668.

There is nothing in any of Venner's writings to indicate that he had, in even the smallest degree, the viewpoint of a scientific investigator, or was really interested in science. His attitude towards his subject is that of the oracle dispensing wisdom—much of it good wisdom to be sure, but oracular—rather than that of the student intrigued by the problems which the attainment of longevity presents. His pronouncements are *ex cathedra;* the inspired and therefore dogmatic precepts of the learned physician to his patients, delivered in the perfect bedside manner which at once informs, guides, reassures, and comforts.

Venner lived in one of the great periods of human history. The culmination of the English Renaissance was in the great writers of Elizabeth's time. Venner himself lived in the same little English world with Spenser and Shakespeare; he may have known them, as well as

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[10] Diary of Samuel Pepys, F. R. S. *Everyman Edit.*, ii, p. 528.

Bacon, Harvey and Sir Thomas Browne. In the great world of Europe his life overlapped those of Paré, Caesalpinus, Fabricius, Bruno, and was almost wholly contemporary with that of Galileo. Before Venner had completed his long life such personages as Sydenham, Boyle, Locke, and the great Newton had come upon the scene, and the era of science, in the modern sense, had begun.

Perhaps a clearer idea of the yeasty world in which Venner lived his life may be got from Fig. 2, which I have ventured to call his *Biogram*.[11]

THE BOOK

The title page of my copy of the *Via Recta*, which is the final edition, is shown in Fig. 3.

The collation of the book is as follows: 4^0. A — Z^4, Aa — Zz^4, Aaa — Fff^4, Ggg^2. Pp. [8] + 404 + [8]. 34 lines + headline and signature and catchword lines, 156 (165) × 93 mm. [A1^a] blank, [A1^b] frontispiece, [A2^a] title-page, [A2^b] blank, A3^a and A3^b *Lectori salutis cupido*, A4^a *Regulæ quindecim* etc., A4^b The Contents. B1^a — Uu4^a (pp. 1-335) include the 13 sections of the *Via Recta* proper; Uu4^b (p. [336]) blank; Xx1^a [p. 337] title page of *The Baths of Bathe* [*cf.*, Fig. 4]; Xx1^b (p. 338) To the Reader [*i.e.*, a preface]; Xx2^a — Aaa1^a (pp. 339-361) the text of the *Baths of Bathe;* Aaa1^b (p. [363])

[11] The idea of this type of diagram to depict graphically the events of history came to me over a quarter of a century ago, and was set down in rough form in an early notebook. It has been independently hit upon in precisely the same form by at least one other person, my friend Dr. A. J. Lotka, as he told me in conversation some years ago when he was working in my laboratory. So far as I know neither of us has hitherto publicly used it in connection with a historical discussion, though I published the same type of diagram in 1926, in dealing with the question of span of life and average duration of life (*Natural History*, Vol. 26, pp. 26-30, 1926).

The essence of the idea is to plot the life of an individual as a *slanting* straight line on a coördinate grid, of which the abscissa is calendar date, and the ordinate duration of life in years. By proper choice of scales the individual life lines may be made to slant to any desired degree. Reading against the abscissal scale we see what historical period the individual's life covered. Reading against the ordinate scale we see how old he was when he died. Reading against both scales we can see how old he was at any particular date. Finally we can, as in Fig. 2, reconstruct at a glance a skeleton outline of the world in which he lived.

In the absence of a better designation, and because of a different connotation of the word "biograph," I suggest "biogram" as an appropriate label for such a drawing as that shown in Fig. 2.

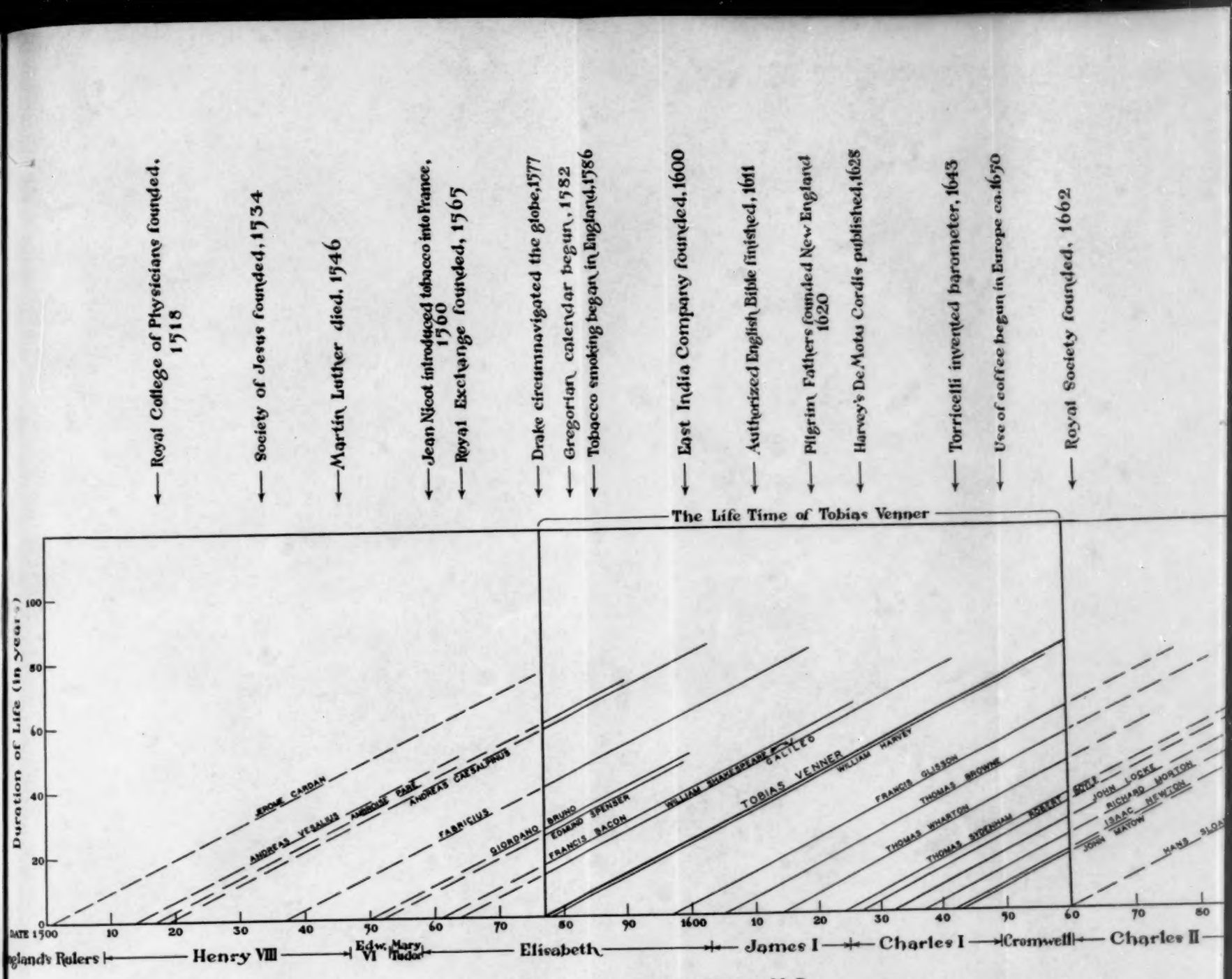

FIG. 2. BIOGRAM OF TOBIAS VENNER, M. D.

See footnote 11 for explanation. Each slanting line in the diagram represents the life of the individual whose name stands above it (or from whose name an arrow runs to the
rtions of the life lines are contemporaneous with some part of Tobias Venner's line; the dash portions lie outside of his life-time. Shakespeare and Galileo were born in the same
nce have a single life line; Shakespeare's part of the line ends at 1616 (the year of his death), Galileo's goes on to 1642.

AS VENNER, M. D.

lividual whose name stands above it (or from whose name an arrow runs to the line). The solid ns lie outside of his life-time. Shakespeare and Galileo were born in the same year (1564) and lileo's goes on to 1642.

VIA RECTA
AD
Vitam Longam.

OR,

A Treatiſe wherein the right way and beſt manner of living for attaining to a long and healthfull life, is clearly demonſtrated and punctually applyed to every age and conſtitution of body.

The fourth IMPRESSION, *amplified with many profitable* ADDITIONS.

By TOB. VENNER Doctor of Phyſick in *Bathe*.

WHEREUNTO
Is annexed a very neceſſary and compendious TREATISE of the famous Baths of *Bathe*;

WITH
A Cenſure of the medicinal faculties of the Water of St. *Vincent's* Rocks near the City of *Briſtol*.

As alſo
An accurate Treatiſe concerning TOBACCO, By the ſame AUTHOR.

LONDON,
Printed for *Abel Roper* at the ſign of the *Sun* againſt St. *Dunſtans* Church in *Fleetſtreet*, *Anno* 1660.

FIG. 3. THE TITLE-PAGE OF VENNER'S VIA RECTA AD VITAM LONGAM, IN REDUCED FACSIMILE

In the original copy from which this photographic reproduction is made the length of the rule under "By Tob. Venner Doctor of Physick in Bathe" is 100 mm.

blank; Aaa2[a] — Bbb2[a] (pp. 363-371) text of *An Advertisement . . . . of the great Utility that cometh by the taking of Physick in the Spring;* Bbb2[b] (p. [372]) blank; Bbb3[a]—Ccc3[b] (pp. 373-382) *Censure Concerning the Water of St. Vincent's Rocks;* Ccc4[a] (p. [383]) title page of *Treatise concerning . . . . . Tobacco;* Ccc4[b] (p. [384]) blank; Ddd1[a] — Fff2[b] (pp. 385-404) text of *Treatise concerning . . . . . Tobacco;* Fff3[a] — Ggg2[a] [pages unnumbered] A Table Directing to the principal things contained in these Treatises. [*i.e.*, an index], Ggg2[b] Books sold by *Abel Roper* at the *Sun* in *Fleet-street* [*i.e.*, a publisher's advertisement]. The full size of the copy here described is 190 × 140 mm.

As will be seen from the above collation the book consists really of one substantial treatise, the *Via Recta,* and four attached pamphlets. Of these four pamphlets only two are of any importance, the first and the last. Indeed the second and third are really appendices to the first, the *Baths of Bathe.* The title page of the *Baths of Bathe,* and that of the *Tobacco* treatise are shown in facsimile in Figs. 4 and 5.

The titles which are parts of the first text pages of the two appendices to the *Baths of Bathe* are, in full, as follows:

[Below a printer's ornament 21 × 89 mm. as headpiece] AN / AD VERTISEMENT / As an / APPENDIX / TO THE / *PRECE DENT TREATISES,* / Of the great utility that cometh to mans / body, by the taking of Physick in the Spring, in- / ferred upon the ensuing Question. / [single rule]. / [Ten lines of text + signature and catchword line, to fill page].

[Below a printer's ornament 7 × 92 mm. as headpiece] A / CEN SURE / Concerning the / WATER / OF / St. *VINCENT*'S ROCKS / *NEAR* / *Bristol,* * * *Urbs pulcra* | & *Emporium* | *celebre.* | / *Which is in great Request and Use* / *against the STONE.* / [Six lines of text + catchword line, to fill page].[12]

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[12] This title presents an odd little problem in bibliographic description. Footnotes, at the time of this volume, were commonly printed on the lateral margin of the page, and not at the bottom as now. With the suavity and urbanity which characterize his professional manners at all points old Tobias wanted to make it clear that, whatever he might say in a censorious manner about the water of St. Vincent's Rocks, he entertained only sentiments of the highest esteem for Bristol, considered as Bristol. To accomplish this end he attached the little Latin footnote to Bristol. Now the word Bristol is set in Canon = 48 point type. The result is that the three lines of the footnote come entirely within the one line space occupied

THE BATHS OF BATHE.

OR,

A neceſſary compendious *Treatiſe*, concerning the Nature, Uſe, and Efficacy of thoſe famous Hot-waters.

Publiſhed for the benefit of all ſuch as yearely, for their healths, reſort to thoſe Baths.

With an advertiſement of the great utility that cometh to mans body, by the taking of Phyſick in the Spring, inferred upon a Queſtion moved, concerning the frequency of ſickneſſe, and death of people more in that ſeaſon, than in any other.

Whereunto is alſo annexed a Cenſure, *concerning the water of Saint* Vincent's *rocks near* Briſtoll, *which is in great requeſt and uſe againſt the Stone.*

By To. VENNER Doctor of Phyſick in *Bathe.*

LONDON,

Printed by *T. R.* for *Abel Roper*, and are to be ſold at his ſhop at the *Sun* in *Fleetſtreet*, 1660.

FIG. 4. THE TITLE-PAGE OF VENNER'S THE BATHS OF BATHE, IN REDUCED FACSIMILE

In the original copy from which this photographic reproduction is made the rule underneath the line "By To. Venner" etc. is 92 mm. in length. This title-page is folio Xx1[a] of the whole book.

A

Brief and accurate

TREATISE

CONCERNING

The taking of the Fume of

TOBACCO,

Which very many in theſe dayes,
doe too too licenciouſly uſe.

In which the immoderate, irregular,
and unſeaſonable uſe thereof is reprehended,
and the true nature and beſt manner of uſing
it, perſpicuouſly demonſtrated.

By TOB. VENNER Doctor of Phyſick in *Bathe*.

LONDON,

Printed for *Abel Roper*, and are to be ſold
at his ſhop at the *Sun* in *Fleetſtreet*, 1660.

FIG. 5. THE TITLE-PAGE OF VENNER'S TREATISE CONCERNING TOBACCO IN REDUCED FACSIMILE

In the original copy from which this photographic reproduction is made the rule underneath the line "By Tob. Venner" etc. is 92 mm. in length. This title-page is folio Ccc4[a] of the whole book.

Oddly enough the *Via Recta* has been but little noticed in modern times. I have been able to find but one reference to it in the *Index Catalogue* of the Surgeon General's Library, a paper by Dr. John Knott [13] of Dublin. This short paper makes brief quotations, and estimates the book as "worthy of attention as representative of the general professional knowledge at an extremely interesting and important epoch of medical history" (p. 245).

QUOTATIONS

With the technical description of the book now sufficiently disposed of, we may turn to a consideration of its contents. The *Via Recta* starts with a chapter or "Section" as it is actually called, of 22 pages on the general subject "of the nature and choice of habitable places" and says about the same things that an aristocratic Englishman still loves to say about the importance and characteristics of air and water as contributing to his sense of well-being. The next 271 pages are devoted to a detailed consideration of victuals and drink, of which more anon. Finally four short chapters deal respectively with: "Of sleep and Watching"; "Of Exercise and Rest"; "Of Excretions"; and "Of Perturbations, or Passions of the mind."

The greatest interest of the book lies in the sections on food and drink. Perhaps the outstanding characteristic of this part of the *Via Recta* is its modernity. A careful perusal of the book leads me to say that but few recommendations as to diet contained in the latest treatise based upon the newer (and even newest) knowledge of nutrition are not already discussed in the *Via Recta,* either directly and specifically with advice identical with that given today, or inferentially. The dietary ingredients recommended today as rich in vitamin content are no more strongly advocated by McCollum than by Venner, broadly speaking. As an example, consider the summing up of a couple of pages of discussion of the dietary virtues of lettuce (p. 200):

> But whether it be eaten raw, or boyled, as the constitution of the body shall require, this is certaine, that there cannot be found any simple medicinable meat, wherewith sleep may be procured, & the unquietness of the spirits, and heat of

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by the word Bristol. The manner in which I have endeavored to indicate the facts in the transcription seems to me to be extremely neat and effective. I can only hope that the approval of professional bibliographers will be as enthusiastic as mine is.

[13] Knott, J. Dr. Tobias Venner: his "Via Recta ad Vitam Longam." *St. Louis Med. Rev.*, Vol. 50, pp. 245-6, 1904.

choler appeased, as with it. It is of all hearbs, the best and wholesomest for hot seasons, for young men, and them that abound with choler, and also for the sanguine, and such as have hot stomacks. It cannot be spoken with how great efficacy, it doth, being eaten with Vineger, extinguish the burning heat of the stomack.

Venner devotes the larger part of a chapter to milk. He starts off by saying (p. 120):

Milk is moist in the second degree, and more enclined unto cold than unto heat; it is of easie digestion, of much and good nourishment: it impinguateth and causeth the body to wax grosse, and for amending of a dry constitution, and for them that are extenuated by long sicknesse, or are in a consumption, it is by reason of the excellent moistening, cooling and nourishing faculty of it, of singular efficacy.

The following passage about the kinds of milk and the pleasantness of cream is entertaining (pp. 123-4):

But of milk, there is great difference according to the kinds of it. Cowes milke for sound and healthfull bodies is best, for it is fattest and thickest, and consequently of most nourishment: Next unto it for grosseness, is Sheeps milk. But for bodies that are with long sickness extenuated, or are in a consumption, womans milk is best, because it is most familiar unto mans body, and even of like nature. And next unto it is Goats milk, because it is of meane consistence; for it is not so fat and thick as Cowes milk, and therefore breedeth not obstructions in the entrails, as that doth; nor so thin as Asses milk, which also in consumptions is much commended: wherefore the nourishment which it maketh, is of a middle nature betweene them both, exceeding wholesome and good. But Asses milk appertaineth rather unto physick than unto meat, for it is of a thin and waterish substance, of a penetrating, cooling, and detersive faculty, by reason whereof, it is of singular efficacy in consumptions of the lungs.

Milk, notwithstanding that it seemeth to be wholly of one substance, yet it is compact of three severall parts, of Creame, Curdes, and Whey. The first is the very head or flower of the milk: it is of a temperate quality, hot and moist in the first degree; it is pleasant to the Palat, and very good for the asperity and siccity of the stomack: but it is somewhat of a gross nourishment, and by reason of unctuosity of it, quickly cloyeth the stomack, relaxeth and weakneth the retentive faculty thereof, and is easily converted into phlegm, and vaporous fumes. Wherefore it is hurtfull to them that be phlegmatick, that have weak stomacks, to old men, and such as are subject unto rheumes, especially in the cold and moist seasons of the year; but unto hot cholerick bodies, and young men that have strong stomacks, it is (especially in the hot seasons of the year) no less convenient than delightsome: and verily with Straw-berries and Sugar, it is for them, for whom it is convenient, a very delicate and wholesome dish. And whosoever he be that delighteth to eat a dish of Cream, let him not be parsimonious of Sugar: for that is the best correctory for it.

Under the awning of any neighborhood restaurant in Paris today one can see the precept of the last sentence put into practice by the great numbers of folk whose favored dessert is a dish of cream, which they plentifully besugar!

The usefulness of roughage in the diet was not unknown to Venner, and in particular he seems to have known rather completely about bran (p. 25):

Bread made only of the branny part of the meal, which the poorest sort of people use, especially in time of dearth and necessity, giveth a very bad and excremental nourishment to the body: it is well called *panis canicarius*, because it is more fit for dogs than for men. But if the grosser part of the Bran be separated by a Searce, and Rie-flower together, or else barley flower and Rie flower together, be added to that which is sifted from the grossest bran, there will be made a brown Houshold-bread, agreeable enough for Labourers. Sometimes only the grosser part of the bran is by a Searce separated from the meale, and a bread made of that which is sifted, called in some places, *One-way bread*, wholesome enough, and with some in very familiar use: it nourisheth lesse than that which is made of purer flower; but by reason of some part of the bran which is contained in it, it doth sooner descend and move the belly, for there is a kind of abstersive faculty in the bran: wherefore for those that are healthy, and yet subject to constivenesse, and also for such as would not wax grosse, it is most profitable.

It should be emphasized, of course, that when Venner spoke of the dietary virtues of such things as lettuce, milk, egg yolk, bran, etc. it was pure empiricism. He knew nothing "scientific," as we now think we do, about why particular foods were useful in the diet. He thought he did, to be sure, but as has been pointed out earlier, his explanations are now quite outmoded. How much more profound our knowledge is, and how thankful we ought to be for the great advances in biochemistry, which enable us to understand scientifically that lettuce is good for us to eat because it contains vitamins A and E.

From the viewpoint of the *gastronome* the *Via Recta* makes it plain that some of the things now esteemed as the greatest delicacies were no strangers to the Elizabethan table, although Venner did not approve of all of them. Thus he pays his respects to frogs and snails in the following passage (pp. 82-3):

There are also divers other kinds of flesh, which poor people in time of scarcity, are oftentimes constrained to make use of; but because they are altogether unwholesome, and alienate from the taste of wholesome meat, I will let them pass; only I marvel why Frogs and Snails are with some people, and in some Countries, in great account, and judged wholesome food, whereas indeed they have in them nothing else, but a cold, gross, slimy and excremental juyce: wherefore I conclude, that they are altogether unwholesome, and that the custome of eating such meat is naught, and that they have very corrupt stomacks, that desire such corrupt meats.

In a similar vein he looks down his nose at caviar (p. 146):

There is an *Italian* sauce called *Caviaro*, which begins to be in use with us, such vaine Affectors are we of Novelties. It is prepared of the Spawn of Sturgion: the very name doth well express its nature, that it is good to beware of it. But this, and other such like noysome sauces, devised only to allure the stomack and palat to meats and drinks, I leave to the beastly and *Bacchanalian* meetings of Drunkards and *Apician* belly-gods.

Mushrooms also get no sympathy (p. 185):

Many phantastical people do greatly delight to eat of the earthly excrescences, called *Mushrums;* whereof some are venemous, and the best of them unwholesome for meat; for they are of hard concoction, corrupt the humours, and give to the body a phlegmatick, earthy, and windy nourishment, or rather detriment. Wherefore they are convenient for no season, age or temperature.

Lack of space prevents the quotation of much that is interesting and sound regarding the more staple articles of diet. The book offers a wealth of material for anyone wishing to make a thorough study of the 16th and 17th century food-habits of the English.

Venner's views on drink are of interest. He starts his discussion of the subject by considering whether one should drink water (pp. 31-2):

Although *Water* be the most ancient Drink, and to those that inhabit hot countries profitable and familiar, by reason of the parching heat of the ambient Air, which doth exceedingly heat, inflame, and dry their bodies; as also because the water, by the heat of the Sun in such Countries, is better clarified than in cold Climats, and consequently of a far better and more pleasing relish, yet to such as inhabit cold Countries, and specially not accustomed thereunto, nor the constitution impensively hot, requiring and forcing the same, it is by the contrary, in no wise agreeable: for it doth very greatly deject their appetite, destroy the naturall heat, and overthrow the strength of the stomack, and consequently, confounding the concoction, is the cause of crudities, fluctuations, and windinesse in the body.

But if any of an hot constitution to asswage thirst shall desire to drink water, let them mixe therewith a little of the juyce of a Limmon, or in want of it, pure white-wine Vinegar, and a little fine sugar, which will make it the more acceptable to the palat and stomack, more easily with lesse fluctuation and windinesse to passe through the body.

He then goes on to tell of the "commodities" of wine (pp. 32-3):

Many and singular are the commodities of Wine: for it is of it selfe, the most pleasant liquor of all other, and was made from the beginning to exhilarate the heart of man. It is a great increaser of the vital spirits, and a wonderfull restorer of all powers and actions of the body: it very greatly comforteth a weak stomack, helpeth concoction, distribution, and nutrition, mightily strengtheneth the naturall heat, openeth obstruction, discusseth windiness, taketh away sadnesse, and other hurts of melancholy, induceth boldnesse and pleasant behaviour, sharpeneth the wit, abundantly reviveth feeble spirits, excellently amendeth the coldnesse of old

age, and correct the tetrick qualities which that age is subject unto; and to speake all in a word, it maketh a man more couragious and lively both in mind and body. These are in generall the commodities of Wine, which are so to be understood, as that a mean and frugality be bad[14] in the use of it, not intemperancie and drunkennesse; otherwise, what can be more hurtfull than wine, seeing that the same immoderately taken, destroyeth the life and prosperous health, disturbeth the reason, dulleth the understanding, confoundeth the memory, causeth the Lethargy, Palsie, trembling of the hands, and a generall weaknesse of the sinews? Wherefore let Wine be moderately used, that neither distillation, nor inflammation, nor exiccation, or drunkennesse follow; for if it be taken beyond measure, it will not be a remedy and comfort for the strength, but rather a poyson and utter overthrow.

There are next considered in detail the wines in use at the time, and here much entertaining information is to be found. Having disposed of the wines, Venner turns to beer. The discussion culminates in the following passage, quoted in full because it illustrates so perfectly the minute particularity of Venner's treatment of a subject, and also because the home-brewers of today may be interested in the light it throws on the practices of the home-brewers of three centuries ago (pp. 53-56):

How many properties ought there to be in the best and wholesomest Beere?

Six: The first is, that it be not sowre, or of any other unpleasant savour, for such is hurtfull to the stomack. The second is, that it be clear and thin; for that which is not clear and well defecated, abundantly increaseth grosse, flatuous, and pituitous humors, and so consequently impinguateth the body, to the utter subversion of it, for it obstructeth the bowels, causes the stone and strangury, by filling the passages of the urine with grosse, fæculent, and slimie humors, breedeth wind, and maketh the breath short and painefull. The third is, that it be very well boyled: for that which is not well boyled, is fulsome to the stomack, and puffeth up the body with windy humours. The fourth is, that it be old, and purged from his dreggs, for such is of a penetrating nature, of good juyce, not windy, but acceptable to the stomack, both for concoction and distribution. But that which is new, causeth the same hurts, which the grosse and not well concocted doth. And verily this property is in Beer much to be regarded; for if it be not drunk, till the bitternesse of the hop be well consumed, it doth nothing lesse than offend the braine and sinews with vaporous fumes; but it doth the better penetrate and quench the thirst: and therefore stale beer is chiefly to be desired in the Summer, and it is a drink (beleeve me) for all constitutions, but especially for the cholerick and melancholick most wholesome.

[14] In these quotations I have let the numerous printer's errors stand as they are in the original. Mostly they do not interfere with the sense. Here, however, is one that does. What Venner undoubtedly wrote was "had," not "bad." R. P.

A meetly large draught of stale beer of an indifferent good strength, taken in the morning fasting, or a little before meals with a little fine Sugar in it, exhilarateth the heart, cleanseth the stomack and bloud, and expelleth melancholy; and at such times thus used it profiteth more than wine.

But here by the way it is to be considered, that as Beer very new is unwholesome, so is that also which is too old, as when it is grown sowre and tart, for it very much hurteth the stomack the liver and the brain. Therefore they greately erre, that keep Beer till it be a year or two old, for it is most hurtfull to the body and pernicious to the understanding. But Beer of a middle age, as from 6 weeks, or 2 months old, unto five or sixe, according to the strength of it, is the best and wholsomest. And if in that space, it shall only chance to acquire somwhat a sowre smack, not an acrimonious Sharpenes, it is not therefore of all men to be refused: for unto cholerick bodies, because it represseth the acrimony of choler, and also to them (by reason of the penetrating force which it obtaineth) that are subject to the obstruction of the stomack, meseraick veines, spleen, liver, lungs, and reines it is most profitable. And if such as have the stone, or are subject to the obstructions of the reins, doe daily use such Beer, it will be impossible (so that they erre not in other things) that they should ever be vexed with the stone or any other great and painfull obstruction of the reines. The fifth is, that it be of an indifferent strength, not too strong, nor too small, because each excesse is hurtfull. For that beer which is of a middle strength doth heat that state of body which is over-cold, refrigerateth that which is too hot, and preserveth the temperate. But that which is stronger than a meane is more meet for cold and moist bodies, especially in the cold seasons of the year: and that which is weaker for hot and dry bodies, especially in the Spring and Summer: for such bodies require much cooling and moistning, which small beer, because that it little deffereth from the nature of water, doth best effect; but it is rheumatick, and impensively hurfull to cold constitutions: for you must understand, that beer, by how much the stronger it is, by so much the neerer it cometh unto the nature of Wine; and by how much the smaller, by so much the neerer it approacheth unto the nature of water. Wherefore seeing that there is great difference to be found in Beer, according to the strength and smalness of it, it becometh every man to have speciall respect of his own state and temper of body, that thereby he may use of that which shall be best agreeing to his nature. And here I advise all such as respect their own good, that they drink not beer that is very strong, but in stead of wine: (for if it be stale, well depurated from dregs, and throughly boyled, it is in operation most like Wine) because the often use of it is very greatly hurtfull to the integrity both of mind and body. And here I admonish our common Ale-pot-drunkards, that it is worse to be drunke with Ale or Beer, than with wine; for the drunkennesse endureth longer to the utter ruine of the brain and understanding, by reason that the fumes and vapors of the Ale or Beer that ascend to the head, are more grosse, and therefore cannot be so soon resolved, as those that rise up of wine: and by the same reason I conclude, that it is worst of all to be drunk with Ale. The sixt and last property is, that the Malt whereof the Beer is made be of a full pure Corn, as of Barley or Oats, for then the drink made thereof must needs be the better.

On the habits of life Venner has much that is interesting to say. Only a few illustrative passages can be quoted here. For the first may be taken his remarks on radical changes in diet, for such purposes as reducing weight, etc. What doctrine could be sounder than the following (pp. 244-5)?

An ill accustomed diet is not to be changed but with foure cautions. The first is, that it be not done rashly, or too suddenly, but with good advisement, and by little and little: for all sudden mutations are to be eschewed as injurious unto nature. The second is, that it be not done, but in time of perfect health, because the strengths and faculties of the body are then best able to undergoe the change. The third is, that it be not done, but in time of leisure and vacancy from great and serious businesses, that may distract the spirits. The fourth and last is, that it be not done in the declining or old age, but in the youthly or constant, which extendeth to the 50. year of our age, when the strengths and powers of the body are constantly strong. For if an old man, though but entered within the limits of old age, whose strength begins more and more to decline, shall endeavour to alter a long familiar course of life, though hurtful, it is much to be feared, lest that in making a change of his custome, a sudden and unexpected change of his life likewise ensue. I knew a very learned Physician, and of an excellent habit of body, that a long time sacrificing too much to his palat and belly, acquiring such a turgid or strouting-out belly, and massive body, as at length was so troublesome, and burthensome unto him, that about the fifty fourth yeare of his age, to reduce his body to a competent bignesse, he resolved to adventure upon a change of his Diet, *viz.* to eat lesse, and to drink more sparingly: which he did, and for some small time proceeded, as he thought, very successfully in his purpose. But what was the event? Within the compasse of a year *diem ultimum obiit*

The number of meals to be taken per day called forth Venner's best dialectic powers, and the discussion, furthermore, throws light on the domestic customs of his times. In the following passage, which, for lack of space, cannot be quoted in full, we get the perfect picture of the man—the pompous, but nevertheless intelligent physician, catering to the gentry, careful not to be too rough with his customers, but still giving them good advice (pp. 248-253):

Whether the ordinary use of two meales in a day, be best for the preservation of health?

I answer, omiting the precise observation of the time, Country and custome, that the use of two competent meales in a day, *viz.* of Dinner and Supper, is generally best for them that are within the limits of 25. and 60. years, leading a studious, or sedentary kind of life, if they desire to avoid crudity, the original of most diseases, but such as use much exercise or labour, or are of a hot and cholerick temperature, may eat oftner, as three times in a day, and that more largely at each meal, for the restitution of the substantiall moisture, which by reason of exercise, and a strong natural heat, is much exhausted. Wherefore I

advise them, not to be altogether fasting till dinner, but to break their fast, with a threefold caution: that they find their stomacks to be cleane and empty, that the break-fast be slender, and that of meats of light digestion; and that it be taken about four houres before Dinner. And here I may not omit to advertise all such as have plethorick and full bodies, especially living at rest, and which are of a phlegmatick temperature, that they not onely eschew the use of break-fasts, but also oftentimes content themselves with one meal in a day: for by this meanes nature being for a time disburthened, as it were of meats, useth all her power in digesting and expelling the reliques, whereby it cometh to passe that the over-plus of bloud is abated, raw humors concocted, all manner of excrements expelled, and the whole body consequently reduced to a sound and healthy mediocrity. Here it may be demanded of such, as for the health of their bodies, can oftentimes be contented with one meal a day, whether it were better to take it at Supper, than at Dinner? Whereunto I answer, that at Supper, because in the night season and in sleep, the spirits are more intense to concoction, being not withdrawne unto outward and animall actions; yet with this proviso, that they sup not late, for great and late Suppers are very offensive to the whole body, especially to the head and eyes, by reason of the multitude of vapors that ascend from the meats that have been plentifully received. Wherefore they must, after Supper refraine from sleep, or lying downe, three houres at the least, and be sometimes walking, sometimes standing, and sometimes sitting, that the meats may be the better digested, and passed from the stomack, the vapours in some measure consumed, the eyes, and the whole head consequently lesse annoyed. But if any shall erroneously accustome the use of one meal in a day, and shall then lurch and devoure so much, or more, as may well serve for two competent refections, as some, that usually make but one meal in a day, are wont to do: I must tell them, that two moderate refections were far more commendable, and better for their health, than unreasonable feeding & glutting of themselves at once, whereby all the powres and faculties of the body are oppressed, the stomack weakned, crudities and obstructions occasioned.

Here also may those demand, that usually make two meals a day, what space of time ought to intercede the refections? our usuall time for Dinner in all places, is about eleven of the clock; and for Supper in most places, about six, according to which rule, we commonly sup about 6 hours after we have dined, allowing an houres space for a meale. I do well approve of the distance between the meals, and also of the allowance of an houres space for a meale; but if Students, that may command the time, and others also, that lead a generous kind of life, shall alter the time for refection; as to dine about ten and to sup about five, or six, according as their appetites, strengths, and disposition of body shall require, they shall have my better approbation. . . . . .

And here I advise all such as are solicitous of their health, to observe at their meales three things, which I adde as an Appendix to that which hath been spoken.

The first is, that putting aside all businesses, and shaking off all serious cogitations, they take their repast quietly and merrily, and not eat, or come to their meat, *animo meditabundo,* with a troubled or meditating mind: for that will make a distraction in the body, pervert the concoction, and cause the meats to corrupt in the stomack, by reason of the retracting of the spirits to the head: and therefore

at your meates entertain decent and moderate mirth, pleasant discourses, instrumental and vocal delights sometimes, *&c.* which will cheere up the Spirits and as it were vivifie the whole body. ***Edendum, bibendum, ridendum, ludendum, sed intra dulcissimæ moderationis & continentiæ sanctissimæ fines.*** The second is, that they give the meat due preparation for the stomack, which is the exact chewing of it in the mouth: for the well chewing of the meat, is a great furtherance to the well digesting of the same: and therefore they greately erre, that eat over greedily, and snatch up their meat hastily, because it is both hurtfull and indecent. The third is, that they reside not in the chaire of intemperance, that is, prolong the time in eating and drinking superfluously, but only sit so long at meal, as that they may give unto Nature a competent refection: for the ingestion of too much meat, is burthensome and injurious to all the body. But if they shall at any time exceed in eating and drinking, they must make amends with a following parcity; as if the dinner shall be larger than ordinary, let the supper be the lesse, or none at all: for there is no man, albeit very carefull of his health, which doth not in this now and then transcend his limits.

On the subject of bodily habitus in relation to health and longevity Venner has some remarks essentially similar to views of the present day, except in the manner of their expression (pp. 285-287):

A fat and grosse habit of body is worse than a leane, for besides that it is more subject to sicknesse, it is for all corporall actions far more unapt. They are more sickly that have grosse and full bodies, not only because they abound with many crude and superfluous humors, but also because they lesse (by reason of the imbecillity of their heat) resist extrinsecal and intrinsecall causes that demolish their health. And because they are repleated with grosse humours with a naturall strictnesse of the veines, they easily incurre the Apoplexie, Epilepsie, Shortnesse and heavinesse of breath, sownings, and sudden death: the influence of the spirits by the nerves and arteries being hindred and stopt. A lean habit of body is also evill, because the naturall heat is through defect of moisture soon dissolved, breathed forth, and wasted; yet it is lesse evill than a grosse, because men of a leane habit of body are commonly a long time healthy; having good appetites, and strong stomacks for digestion: whereas on the contrary, such as are of a grosse habit of body, have commonly weak stomacks, and for want of good concoction accumulate many superfluous humors, by meanes whereof they have often conflicts with sicknesse. But this which hath been said, is not so to be understood, as that every grosse habit of body is worse than a leane, for we must in this manner distinguish thereof. There is a grosse habit, and the same phlegmatick, and such is altogether evill, and to be abhorred, and of this is to be understood that which I have above said. For in phlegmatick fat bodies is little bloud, but abundance of grosse indigested matter, which makes them subject to prolixe diseases of very difficult cure, and oftentimes through interception of the spirits to sownings and sudden death, as aforesaid. Also there is a grosse habit of body, and the same sanguine, not so evill, by reason of the dangers of repletion. And verily this grosse habit of body is better than the leane, by reason of the plenty of heat and moisture, wherein life consisteth, and therefore not to be

abhorred, so as it doth not in such sort exceed, as it may occasion perillous hurts. But it is to be abhorred, if it be superfluous and transcendent, because it suddenly induceth vomitings of bloud, and such like most perilous accident. But between these two habits there is a meane, which is neither too fat, not too leane, or extenuated, and that verily is the best, because the mediocrity of habit and constitution, cannot be but through goodnesse of the composition, which a strong digestive faculty and strength so firme do follow, as that they can all morbificall causes very easily resist.

Venner's divisions of the ages of man are interesting. He discusses them at some length (pp. 287-292) from the point of view of the diet most appropriate to each. He distinguishes seven ages of man, giving the limits in years of each. In the table which follows are given his designations and the age limits that he assigns, and for comparison Shakespeare's designations of the seven ages of man in the speech of Jacques in *As You Like It* (Act II, Scene VII, L. 139).

Shakespeare's Designations	*Venner's Designations*	*Venner's Age Limits*
"the infant"	"the Infant age"	Birth to 4th year
"the whining school-boy"	"the Boy's age"	4th to 14th year
"the lover"	"the youthly Age"	14th to 25th year
"a soldier"	"age of young men—the flourishing and lively age"	25th to 35th year
"the justice"	"the constant and manly age"	35th to 50th year
"the lean and slippered pantaloon"	"the declining age—*Senectus viridis*, the vigorous, or first old age"	50th to 63d year
"Last scene of all, . . . is second childishness"	"the last age, which is properly called old age"	——[13] 63d year to end of life
		"decrepit old age" 70th year to end of life

The obvious parallelism in sense between the first two columns of the above table is intriguing, but I am unable to undertake any thorough discussion of the matter at this time. A division of man's life into seven ages, though an unnatural one biologically (in the sense that there are no compelling biological reasons for a division into seven periods)

[13] Venner gives no special designation to the period between 63 and 70, but says (p. 290) that the old age period "may well be divided in two parts" of which the second (from 70 on) is "properly called the decrepit old age."

greatly antedated either Shakespeare or Venner. Proclus (412-485 A. D.), the neoplatonist, for example, is said to have divided the life span as follows [16]:

	Ages	*Years*
1.	Infancy	Birth to 4th year.
2.	Childhood	4th to 14th year.
3.	Youth	14th to 22d year.
4.	Young manhood	22d to 42d year.
5.	Mature manhood	42d to 57th year.
6.	Old age	57th to end of 68th year.
7.	Declining and decrepit age	69th to 88th year.

The question of the changes in the individual organism with time (that is, with advancing age) is one of the most interesting and significant in biology. The history of ideas about it merits thorough study. It would probably be rewarding in a variety of directions.

[16] *Cf.* Evans, J. The Progress of Human Life: Shakespeare's Seven Ages, etc. Second edit. *Chiswick*, 1823, pp. 70-73. For lack of time I have not yet been able to verify from the writings of Proclus the material discussed by Evans in this passage. Evans's book is in no sense a scholarly treatise, but is a parson's compilation of inspirational matter garnered from his old sermon barrel and the pietistic literature of the time. I would therefore recommend cautious reserve in accepting any statement he makes appertaining to any matters other than the transcendent wisdom and goodness of God, in which field he is impeccably sound.

RECENT LITERATURE

USEFUL IN THE STUDY OF HUMAN BIOLOGY

In this department will be noticed the books and reprints which are currently received at the Editorial Office. Publications intended for notice here should be addressed to Dr. Raymond Pearl, Department of Biology, School of Hygiene and Public Health, 1901 East Madison Street, Baltimore, Maryland, U. S. A.

1. EVOLUTION AND GENETICS

1. *Evolution—General Principles*

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